OFFICE OF RIVER PROTECTION
P.O. Box 450, MSIN H6-60
Richland, Washington 99352

16-TF-0115

OCT 1 1 2016

Ms. Alexandra K. Smith, Program Manager
Nuclear Waste Program
Washington State
Department of Ecology
3100 Port of Benton Blvd.
Richland, Washington 99354

Ms. Smith:

THE U.S. DEPARTMENT OF ENERGY, OFFICE OF RIVER PROTECTION SUBMITS THE RETRIEVAL DATA REPORT FOR TANK 241-C-102

Reference: ORP letter from K.W. Smith to J.A. Hedges, Ecology, "The U.S. Department of Energy, Office of River Protection Submits the Retrieval Completion Certification Report for Tank 241-C-102," 15-TF-0116, dated November 30, 2015.

The U.S. Department of Energy, Office of River Protection is transmitting RPP-RPT-59631, *Retrieval Data Report for Single-Shell Tank 241-C-102,* Rev. 0, completed in accordance with the requirements of the Hanford Federal Facility Agreement and Consent Order Milestone M-045-86, "Submit a retrieval data report to Ecology for the 19 tanks retrieved under the Consent Decree in *Washington v. DOE,* Case No. *08-5085-FVS..."* RPP-RPT-59631, Rev. 0, documents completion of waste retrieval and post-retrieval sampling at Tank 241-C-102 using modified sluicing as a first retrieval technology and high pressure water as a second retrieval technology.

The retrieval completion certification for Tank 241-C- 102 was transmitted to the Washington State Department of Ecology on November 30, 2015 (Reference).

If you have any questions, please contact Ben Harp, Assistant Manager for Tank Farm Project, at (509) 376-1462.

Cowell FOR
Kevin W. Smith
Manager

TF:JJR

Distribution: Page 2

cc w/attach:
TPA Administrative Record
Environmental Portal, LMSI
WRPS Correspondence

cc:
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Attachment

16-TF-0115

RPP-RPT-59631

Retrieval Data Report for Single-Shell Tank 241-C-102

Rev. 0

DOCUMENT RELEASE AND CHANGE FORM

Prepared For the U.S. Department of Energy, Assistant Secretary for Environmental Management
By Washington River Protection Solutions, LLC., PO Box 850, Richland, WA 99352
Contractor For U.S. Department of Energy, Office of River Protection, under Contract DE-AC27-08RV14800

Release Stamp

DATE: Sep 20, 2016 HANFORD RELEASE

1. **Doc No:** RPP-RPT-59631 **Rev.** 00

2. **Title:**
Retrieval Data Report for Single-Shell Tank 241-C-102

3. **Project Number:** ☒ N/A

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5. **USQ Number:** ☒ N/A RPP-27195

6. **PrHA Number** **Rev.** ☒ N/A

Clearance Review Restriction Type: public

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Title	Name	Signature	Date
Checker	FIELD, JIM G	*FIELD, JIM G*	09/08/2016
Clearance Review	RAYMER, JULIA R	*RAYMER, JULIA R*	09/20/2016
Document Control Approval	MANOR, TAMI	*MANOR, TAMI*	09/20/2016
Originator	PAPPAS, ALEXANDER D	*PAPPAS, ALEXANDER D*	09/08/2016
Responsible Manager	RUTLAND, PAUL L	*RUTLAND, PAUL L*	09/08/2016

8. **Description of Change and Justification**

9. **TBDs or Holds** ☒ N/A

10. **Related Structures, Systems, and Components**

a. **Related Building/Facilities** ☒ N/A
b. **Related Systems** ☒ N/A
c. **Related Equipment ID Nos. (EIN)** ☒ N/A

11. **Impacted Documents – Engineering** ☒ N/A

Document Number	Rev.	Title

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Document Number	Rev.	Title

14. **Distribution**

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INFORMATION CLEARANCE REVIEW AND RELEASE APPROVAL

Part I: Background Information

Title: Retrieval Data Report for Single-Shell Tank 241-C-102	Information Category: ☐ Abstract ☐ Journal Article ☐ Summary ☐ Internet ☐ Visual Aid ☐ Software ☐ Full Paper ☑ Report ☐ Other
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Trademark/Copyright "Right to Use" Information or Permission Documentation	Yes ☐ NA ☑
Document Number: RPP-RPT-59631 Revision 00	Date: ~~September 2016~~ 9/20/2016 JRR
Author: Pappas, Alexander D	

Part II: External/Public Presentation Information

Conference Name:

Sponsoring Organization(s): DOE/ORP

Date of Conference:	Conference Location:

Will Material be Handed Out? ☐ Yes ☑ No — Will Information be Published? ☐ Yes ☑ No — *(If Yes, attach copy of Conference format instructions/guidance.)*

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Responsible Manager	WRPS		Rutland, Paul L Approved via att. IDMS data file.
Other:			

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Retrieval Data Report for ORP that will be later be submitted by them to Ecology.

APPROVED
By Julia Raymer at 1:14 pm, Sep 20, 2016

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RPP-RPT-59631, Rev. 0

Retrieval Data Report for Single-Shell Tank 241-C-102

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U.S. Department of Energy Contract DE-AC27-08RV14800

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Abstract: This Retrieval Data Report presents information showing that single-shell tank 241-C-102 (C 102) has undergone waste retrieval using two retrieval technologies, each to its limits of technology, using a sluicing system comprised of an extended reach sluicing system (ERSS) and high pressure water. The final estimated volume of residual waste in the tank was ~59,400 L (~15,690 gal). This Retrieval Data Report also summarizes the potential risk to human health from waste remaining in the tank, provides details on the technologies deployed and their respective performances during the waste removal campaigns, and describes measures taken to prevent and detect leaks during waste retrieval operations.

APPROVED
By Julia Raymer at 2:43 pm, Sep 20, 2016

Release Approval Date

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RPP-RPT-59631
Revision 0

Retrieval Data Report for Single-Shell Tank 241-C-102

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Date Published
September 2016

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

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Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC27-08RV14800

EXECUTIVE SUMMARY

This Retrieval Data Report presents information in accordance with the requirements of *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) Milestone M-045-86, due 12 months after the U.S. Department of Energy (DOE) certifies to the State of Washington Department of Ecology (Ecology) that DOE has completed retrieval of a single-shell tank covered by the Consent Decree in Washington v. DOE, Case No. CV-08-5085-FVS, as amended[1,2] (E.D. WA. October 25, 2010). The DOE submitted its certification of retrieval, RPP-RPT-58788, *Retrieval Completion Certification Report for Tank 241-C-102*, to Ecology on November 30, 2015 (15-TF-0116, *The U.S. Department of Energy, Office of River Protection Submits The Retrieval Completion Certification Report for Tank 241-C-102*).

This Retrieval Data Report presents information showing that single-shell tank 241-C-102 (C-102) has undergone waste retrieval using two retrieval technologies, each to its limits of technology, using a sluicing system comprised of an extended reach sluicing system (ERSS) and high pressure water, similar to those used in previous tank waste retrieval operations. The tank C-102 ERSS waste retrieval campaign began April 27, 2014 and was suspended on May 8, 2015, after reaching the limits of technology. The first technology, sluicing, was used exclusively during operations between April 27, 2014 and April 6, 2015. The second technology, high pressure water, was used starting on retrieval operations began on April 8, 2015, and operations from then until May 8, 2015 alternated between the uses of high-pressure water and sluicing. The tank C-102 waste that was removed was transferred to double-shell tank 241-AN-101.

The first waste retrieval technology removed the majority of the waste inventory. Following completion of retrieval using the second technology the upper confidence level residual waste volume contained within tank C-102 is estimated to be 59,393 L (15,690 gal) (RPP-RPT-59004, *Post-Retrieval Camera/CAD Modeling System Waste Volume Estimate for Tank 241-C-102*).

RPP-RPT-58676, *Practicability Evaluation Request to Forego a Third Retrieval Technology for Tank 241-C-102*, was then developed to assess whether a third waste retrieval technology should be implemented at tank C-102. RPP-RPT-58676 was issued in November 2015. The Practicability Evaluation Request concluded that the two waste retrieval technologies deployed at tank C-102 had each been deployed to its respective limits of technology, and that implementation of a third technology was not practicable as that term is used in Appendix C, Part 1, of the Consent Decree in Washington v. DOE, Case No. 08-5085-FVS. Ecology agreed with the Practicability Evaluation Request (15-NWP-177, *Re: Response to United States Department of Energy Letter 15-TF-0073, dated August 10, 2015, "Request for Washington State Department of Ecology Agreement that the U.S. Department of Energy, Office of River Protection may Forego Implementing a Third Retrieval Technology in Tank 241-C-102"*).

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[1] The 2010 Consent Decree has been amended twice along with a change in presiding judge. As to the former, the initials "-FVS" were those of Judge Fred Van Sickle, who recused from the case on October 14, 2014, and was replaced by the current presiding judge, Rosanna Malouf Peterson, hence the new case designation "-RMP".

[2] The 2010 Consent Decree has been amended twice. See Amended Consent Decree, Case No. CV-08-5085-RMP (March 11, 2016) and Second Amended Consent Decree, Case No. CV-08-5085-RMP (April 12, 2016). Note that the Amended Consent Decree and Second Amended Consent Decree did not re-publish the provisions of the 2010 Consent Decree but only published those portions of the text that were modified by each decree; consequently, it is necessary to refer to each document to determine whether a particular section has been amended.

RPP-RPT-58788 documents that the two retrieval technologies deployed in tank C-102 retrieved the waste in tank C-102 to the limits of those technologies as required by the Consent Decree. This Retrieval Data Report (RPP-RPT-59631) summarizes the potential risk to human health from waste remaining in the tank, provides details on the technologies deployed and their respective performance during the waste retrieval campaigns, and describes measures taken to prevent and detect leaks during waste retrieval operations.

The tank C-102 leak detection, monitoring, and mitigation program used during retrieval operations consisted of high-resolution resistivity techniques along with readings from a combination of drywell moisture measurements, waste volume assessments (mass balances), and visual inspection to detect and control potential leaks. No leaks were detected during tank C-102 retrieval operations.

Prior to retrieval, the best estimate of waste volume was ~1,120,000 L (~316,000 gal), per RPP-RPT-43029, *2009 Auto-TCR for Tank 241-C-102*. After the retrieval operations (as of June 2013, per RPP-CALC-60351, *Preliminary Estimate of Residual Waste Volume for Single-Shell Tank 241-C-102*), the estimated volume of waste remaining in the tank was ~75,700 L (~20, 000 gal). The final estimated volume of waste remaining in the tank was ~59,400 L (~15,690 gal) (95% upper confidence level of waste volume, as described in RPP-RPT-59004).

The inventory of constituents in the residual waste remaining in tank C-102 was determined by laboratory analysis of waste samples. The risk assessment for the residual waste in tank C-102, based on sampling analysis, shows that for the groundwater pathway, the estimated dose impacts (representing risk) for tank C-102 are two to three orders of magnitude below the performance objectives. For all inadvertent intruder scenarios other than the suburban garden scenario (a sensitivity case) at 100 years after closure, the estimated dose impacts for tank C-102 were well below current performance measures (i.e., 500 mrem for acute exposure and 100 mrem/yr for chronic exposure). Dose impacts from the suburban garden scenario were the highest for all the chronic exposure scenarios and exceeded this performance measure for that scenario 500 years after closure. The estimated doses were below the performance measure of 100 mrem/yr for chronic exposure by 500 years post-closure per DOE Manual 435.1-1 Section IV.P.(2)(h).

CONTENTS

APPENDICES

FIGURES

TABLES

TERMS

BBI	best basis inventory
BBIM	best basis inventory maintenance
CAD	computer-aided design
CCMS	camera/computer-aided design modeling system
DOE	U.S. Department of Energy
DST	double-shell tank
Ecology	State of Washington Department of Ecology
ERSS	extended reach sluicing system
ICP	inductively coupled plasma
ILCR	incremental lifetime cancer risk
LDMM	leak detection, monitoring, and mitigation
MTCA	Model Toxics Control Act
ORP	DOE Office of River Protection
PA	performance assessment
PUREX	Plutonium Uranium Extraction (Plant)
QA	quality assurance
RDR	Retrieval Data Report
RSD	relative standard deviation
SST	single-shell tank
TIC	tentatively identified compound
UCL	upper confidence level
WMA	Waste Management Area

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1. INTRODUCTION AND BACKGROUND

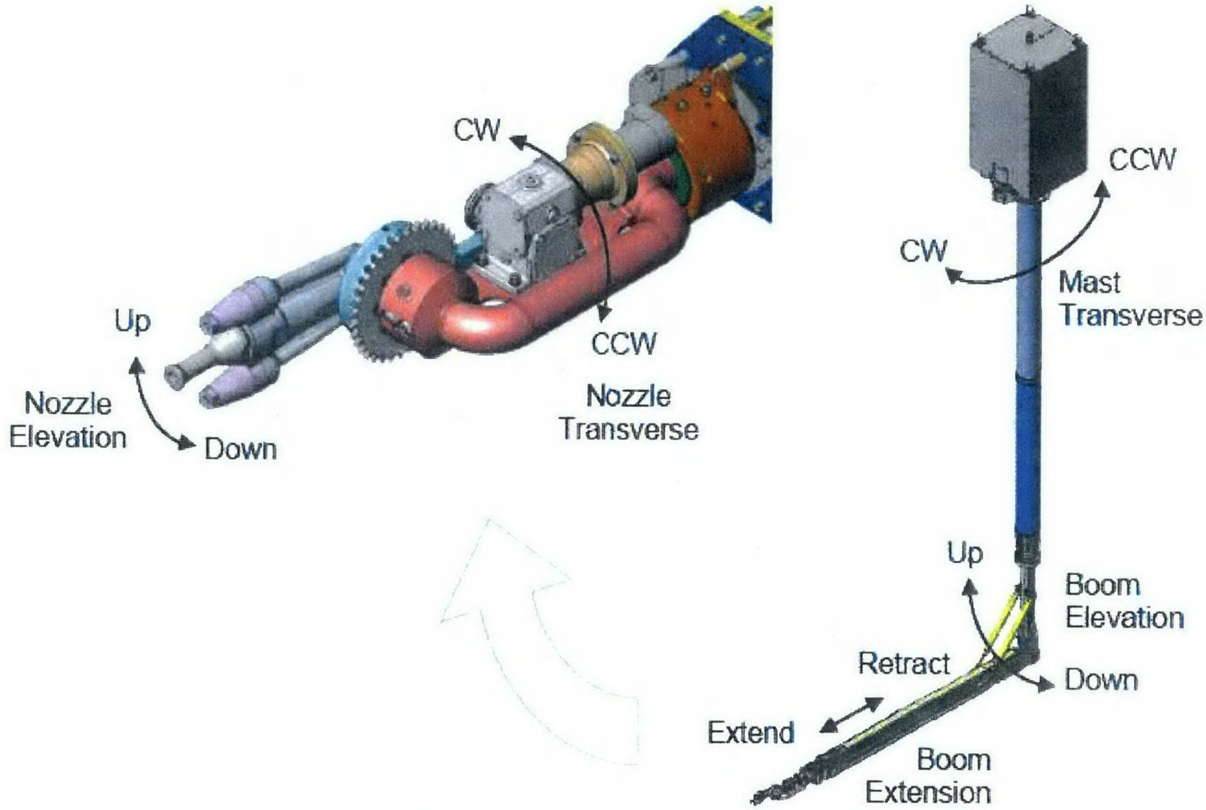
Retrieval of single-shell tank (SST) 241-C-102 (C-102) waste was conducted by implementing two waste retrieval technologies. At the start of retrieval operations, the tank was reported to contain 1,200,000 L (316,000 gal) of sludge comprised of a mixture of Plutonium, Uranium, Redox, Extraction (PUREX) plant aluminum cladding waste generated from 1956 to 1960 and 1961 to 1972 (82 vol%), PUREX decladding waste from the processing of zirconium clad fuel (3 vol%), tri-butyl phosphate waste from the uranium recovery process (5 vol%), high level thorium waste (8 vol%), and residual metal waste generated from 1944 to 1949 (2 vol%). These wastes are described in RPP-RPT-57458, *Derivation of Best-Basis Inventory for Tank 241-C-102 as of March 16, 2016*.

Retrieval of tank C-102 stored waste was conducted between April 27, 2014, and May 8, 2015. It was performed using the modified sluicing system with an extended reach sluicing system (ERSS) and high-pressure water nozzles with recycled supernate, similar to previous tank waste retrieval operations. The tank C-102 modified sluicing and high pressure water nozzle campaigns were approved by the State of Washington Department of Ecology (Ecology) in Revision 7 of RPP-22393, *241-C-102, 241-C-104, 241-C-107, 241-C-108, and 241-C-112 Tanks Waste Retrieval Work Plan*. Tank C-102 was declared retrieved to the limits of these technologies with a preliminary volume estimate of 75,700 L (20,000 gal) of waste remaining based on liquid displacement measurement and visual evaluation (RPP-CALC-60351, *Estimate of Residual Waste Volume for Single-Shell Tank 241-C-102*; RPP-RPT-58281, *Retrieval Completion Report for Modified Sluicing of Tank 241-C-102 Using Extended Reach Sluicing and High Pressure Water*).

The majority of the waste in tank C-102 consisted of a soft brown sludge that could be readily mobilized by the ERSSs and pumped from the tank. The presence of cladding waste from the processing of aluminum-clad fuel suggested that gibbsite ($Al[OH]_3$) was also present. Gibbsite has been a major constituent of hard waste layers encountered in other C farm tanks.

The first technology of modified sluicing using ERSSs (Figure 1-1) was deployed, from April 27, 2014 to April 6, 2015. The sluicing system in tank C-102, which consisted of two ERSSs, was the primary technology for waste retrieval. The rate of waste retrieval was initially high and relatively constant through about the first 635,949 L (168,000 gal) of waste retrieved (~53%), which was reached on July 22, 2014. As the easily retrieved sludge was removed and the larger waste particles with greater density remained, the retrieval rate slowed to a lower rate and then remained relatively constant through 719,228 L (190,000 gal) retrieved by July 30, 2014. Retrieval proceeded at this rate until the slurry pump screen was lowered to ~1.1 m (~3.5 ft) above the bottom of the tank. At that point, a hard surface was encountered which caused difficulties in lowering the slurry pump.

Figure 1-1. Extended Reach Sluicing System with High-Pressure Water Nozzles.



CW = clockwise CCW = counter-clockwise

Sluicing of the riser 2 mound and undermining of the hard layer obstruction under the pump screen was performed between August 1 and August 17, 2014. During this time, hot water was added in an attempt to soften the hard waste under the pump and on the tank walls. A test with hot water sluicing (52°C [125°F]) was performed on August 3, 2014 to evaluate the effectiveness of hot water on the waste under the pump and the hard waste near the walls. Approximately 21,955 L (5,800 gal) of hot water were used in sluicing under the pump and in sluicing some chunks of hard waste near the wall. Approximately 18,548 L (4,900 gal) of hot water were flushed through the slurry pump and allowed to soak for about 5 hours before it was pumped out. No significant impact from hot water was seen. On August 12, 2014, an additional test with hot water sluicing was performed to evaluate the effectiveness of hot water on the hard waste on the tank walls. Again, no significant impact from hot water was seen based on an evaluation of the video of the sluicing location.

Retrieval shut down on August 17, 2014 to replace the riser 2 ERSS, which was leaking hydraulic fluid. Post installation testing of the replacement ERSS in riser 2 was unsuccessful, and it was decided to remove the riser 7 ERSS and replace that ERSS with a long reach ERSS. With the installation on October 17, 2014 of the long reach ERSS in riser 7 the retrieval rate increased and by October 29, 2014 ~787,365 L (~208,000 gal) of waste was retrieved. The retrieval rate remained steady until December 17, 2014, through 927,425 L (245,000 gal) of waste retrieved. From 927,425 L (245,000 gal) of waste retrieved onwards, the retrieval rate slowed.

By January 25, 2015 a total of 999,348 L (264,000 gal) of waste was retrieved. A short reach ERSS was installed in riser 2 on February 19, 2015, which allowed for 1,033,417 L (273,000 gal) of waste to be retrieved by March 21, 2015. During this period retrieval rates improved slightly, then plateaued as the remaining waste consisted of hard chunks around the perimeter of the tank that were very slow to break up under sluicing, and sand to gravel-sized material in the center of the tank that could be pushed around by the ERSSs but not pumped out by the slurry pump.

The second technology of high pressure washing using ERSS was deployed from April 8, 2015 to April 18, 2015. The use of high-pressure water being alternated with periods of supernate sluicing was able to break off small pieces of the hard chunks of waste while creating a small amount of fines, but did not improve the waste retrieval rate.

The waste remaining in the tank includes some pools of liquid in the center of the tank. A layer of fine solids covers most of the tank bottom and the tank floor plates are visible in some areas. Large chunks of "cobble" material are located around the entire knuckle of the tank perimeter. The largest boulders are located on the south side of the tank in the area under riser 2.

Volume displacement measurements and tank video scans were performed before transferring supernate from tank C-102 to tank AN-101 on May 8, 2015. Following the volume displacement measurement, tank C-102 was rinsed with ~189,270 L (50,000 gal) of water. The preliminary residual volume was estimated in RPP-CALC-60351 to be ~75,700 L (20,000 gal). The final video Camera/ Computer-aided design (CAD) Modeling System (CCMS) estimate of the quantity of waste remaining in tank C-102 was 56,800 L (15,000 gal) with an upper 95% confidence level (UCL) of 58,600 L (15,480 gal15,690 gal)(RPP-RPT-59004, *Post-Retrieval Camera/CAD Modeling System Waste Volume Estimate for Tank 241-C-102*).

In accordance with Appendix C, Part 1, of the Consent Decree in Washington v. DOE, Case No. CV-08-5085-RMP (E.D. Wa. October 25, 2010) (hereinafter "Consent Decree"), RPP-RPT-58676, *Practicability Evaluation Request to Forego a Third Retrieval Technology for Tank 241-C-102* was developed to assess whether a third waste retrieval technology should be implemented at tank C-102. The Practicability Evaluation Request RPP-RPT-58676, issued in July 2015, determined that implementing a third technology was impractical under the terms of the Consent Decree, Appendix C, Part 1. The U.S. Department of Energy (DOE) Office of River Protection (ORP) formally requested the State of Washington Department of Ecology (Ecology) to agree with DOE's request to forego implementation of a third technology by way of an August 10, 2015 letter from K. W. Smith to J. A. Hedges (Letter 15-TF-0073), "Request for Washington State Department of Ecology Agreement that the U. S. Department of Energy, Office of River Protection May Forego Implementing a Third Retrieval Technology in Tank 241-C-102"). Ecology agreed with this request on October 2, 2015 via a letter from J. A. Hedges to K. W. Smith (Letter 15-NWP-177, *Re: Response to United States Department of Energy Letter 15-TF-0073, dated August 10, 2015, "Request for Washington State Department of Ecology Agreement that the U.S. Department of Energy, Office of River Protection may Forego Implementing a Third Retrieval Technology in Tank 241-C-102"*).

Where information regarding treatment, management, and disposal of the radioactive source, byproduct material, and/or special nuclear components of mixed waste (as defined by the *Atomic*

Energy Act of 1954, as amended) has been incorporated into this document, it is not incorporated for the purpose of regulating the radiation hazards of such components under the authority of RCW 70.105, "Hazardous Waste Management," (known as the Hazardous Waste Management Act) and its implementing regulations, but is provided for information purposes only.

1.1 PURPOSE

This Retrieval Data Report (RDR) provides information required by *Hanford Federal Facility Agreement and Consent Order* (HFFACO) Milestone M-045-86 (Ecology et al., 1989). The report documents the following aspects of tank C-102 retrieval:

- Residual tank waste volume measurement, including associated calculations
- The results of residual tank waste characterization
- Retrieval technology performance documentation
- DOE's updated post-retrieval risk assessment
- Opportunities and actions being taken to refine or develop tank waste retrieval technologies based on lessons learned
- Leak detection monitoring and performance results.

1.2 REGULATORY REQUIREMENTS

Retrieval of waste from tank C-102 and submittal of this RDR (in accordance with conditions stated in the HFFACO) are necessary requirements for closing the Hanford SST system. The HFFACO Milestone M-045-86 provides in part:

> *Submit a retrieval data report to Ecology for the 19 tanks retrieved under the Consent Decree in Washington v. DOE, Case No. 08-5085-FVS, which report shall include the following elements only of Section 2.1.7 of Appendix I to the HFFACO:*
>
> 1. *Residual tank waste volume measurement, including associated calculations*
> 2. *The results of residual tank waste characterization*
> 3. *Retrieval technology performance documentation*
> 4. *DOE's updated post-retrieval risk assessment*
> 5. *Opportunities and actions being taken to refine or develop tank waste retrieval technologies, based on lessons learned*
> 6. *Leak detection, monitoring, and mitigation (LDMM) monitoring and performance results.*

The Consent Decree in Washington v. DOE, Case No. CV-08-5085-RMP (formerly CV-08-5085-FVS), Appendix C states that "If the waste residual goal of 360 cubic feet (10,194 L) is not achieved using the established two technologies, an additional retrieval technology established in a revised TWRWP *[Tank Waste Retrieval Work Plan]* shall be deployed to the "limits of technology;" provided that DOE may request that the State agree that DOE may forego implementing a third retrieval technology if DOE believes implementing such technology is not practicable under the criteria set forth above *[in Appendix C, Part 1]*." A Practicability

Evaluation was prepared (RPP-RPT-58676) that addressed the limits of technology and concluded that a further waste retrieval action for tank C-102 was not practicable. As noted above, the DOE submitted the Practicability Evaluation to the State of Washington with a request to forego implementing a third retrieval technology, and the State of Washington (Ecology) concurred with that request.

1.3 DOCUMENT STRUCTURE

This tank C-102 RDR is organized to present information required by Milestone M-045-86 of the HFFACO Action Plan.

- Section 1, Introduction and Background discusses the purpose and scope of tank C-102 waste retrieval, presents requirements applicable to this report, and outlines the report structure.
- Section 2, Single-Shell Tank 241-C-102 Residual Waste Volume Measurement describes the method for determining the volume of residual waste in tank C-102 and presents results of the volume measurement process.
- Section 3, Residual Tank Waste Characterization lists requirements for characterization of tank waste, describes methods and procedures used to sample and analyze the waste, and describes the results of laboratory analysis.
- Section 4, Retrieval System Performance provides an evaluation of how well the waste retrieval system performed and provides a comparison of actual performance against predicted performance.
- Section 5, Post-Retrieval Single-Shell Tank 241-C-102 Risk Assessment describes the potential risk to human health from tank C-102 residual waste. This section identifies and discusses contaminants of potential concern in the waste, describes the effects of waste retrieval and closure on long-term human health risk, presents expected cumulative health effects of source terms, relates calculated risk to residual waste volume, and summarizes overall conclusions of the risk assessment. To satisfy recent requests by Ecology, this section also provides additional risk management information related to how concentrations of constituents remaining in waste residuals within tank C-102 compare against the *Washington Administrative Code* (WAC) 173-340, "Model Toxics Control Act – Cleanup" cleanup standards. These soil cleanup standards are developed to be protective of direct contact exposures and groundwater use.
- Section 6, Opportunities discusses recommendations for future actions associated with tank C-102 and actions being taken based on lessons learned.
- Section 7, Leak Detection, Monitoring, and Mitigation describes LDMM methods and procedures, presents an LDMM chronology for tank C-102 waste retrieval, and summarizes LDMM results.
- Section 8, References contains references for material cited in the report.

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2. SINGLE-SHELL TANK 241-C-102 RESIDUAL WASTE VOLUME MEASUREMENT

The waste in tank C-101 was retrieved using modified sluicing and high-pressure water technologies deployed by two ERSS platforms, as described by RPP-22393, Revision 7. A description of the retrieval systems and chronology of the retrieval processes may be found in RPP-RPT-58676. Following retrieval, the residual waste volume was determined. This section presents the residual waste volume measurement process and the results for tank C-102. The post-retrieval residual waste volume estimate was performed using a method described in RPP-RPT-59004. The total measured volume of residual waste in tank C-102 was the sum of volumes remaining in the bottom of the tank, on the Riser 9 sludge pump and tank wall stiffener rings. The residual waste volume used for all calculations in this RDR is the volume reported as the 95% UCL as shown in Table 2-1.

Table 2-1. Tank 241-C-102 Total Waste Volume and Component Waste Volumes.

Component	Waste Volume from CCMS			Actual Volume[a] (L)	Actual Volume (gal)	95% UCL[a] (ft^3)	95% (gal)
	L	gal	ft^3				
On the bottom of the tank (solids)	35,830	9,466	1,265	51,420	13,580	52,220	13,790
Waste on Riser 9 sludge pump	1,160	307	41.00				
On the bottom of the tank (liquid pool)	8,710	2,300	307.5				
On the tank wall and stiffener rings	7,190	1,899	253.9	7,190	1,899	7,190	1,899
Total[b]	52,890	13,970	1,867	58,620	15,480	59,410	15,690

a. Per RPP-23403, *Single - Shell Tank Component Closure Data Quality Objectives*, the actual residual waste volume on the tank bottom is calculated by the formula = 1.125 × CCMS + 0.53 ft^3 and the volume at a 95% upper confidence level is calculated by the equation: 1.132 × CCMS reading + 17.09 ft^3.

b. Total may not equal sum of individual volumes because of rounding.

UCL = upper confidence limit

2.1 RESIDUAL WASTE VOLUME MEASUREMENT PROCESS

The waste volume measurement approach is summarized in Sections 2.1.1 through 2.1.3 and is described in RPP-RPT-59004. The Camera/CAD (computer-aided design) Modeling System (CCMS) method was used to calculate the volume remaining in the tank dish and on the Riser 9 sludge pump. The waste volumes remaining on the tank wall and stiffener rings were estimated using observation, records, and equipment drawings.

Tank C-102 post-retrieval volumes were previously estimated using Enraf[3] displacement and engineering judgment based on video observations (see RPP-CALC-60351, *Preliminary Estimate of Residual Waste Volume for Single-Shell Tank 241-C-102*). However, the Enraf displacement provided only a preliminary estimate of waste in the tank bottom. As a result, a post-retrieval CCMS volume estimate was required per RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives.*

2.2 Video Camera/Computer-aided Design Modeling System

The post-retrieval waste consists of solids piles and a liquid pool (mostly liquid, may be some submerged solids). The volume of this waste was estimated using the CCMS method per TFC-ENG-FACSUP-CD-22. The CCMS videos of tank C-102 were recorded on July 1, 2015 from cameras located in riser 3 and riser 6. Video was recorded at heights of ~3.5 m (11.5 ft) and 5.0 m (16.5 ft) above the bottom of the tank from the riser 3 camera, and recorded at heights of ~1.9 m (6.5 ft), 3.5 m (11.5 ft), and 5.0 m (16.5 ft) using the riser 6 camera.

After the CCMS video was completed, the video was reviewed to develop an AutoCAD® Civil 3D®[4] drawing of tank C-102 and the tank waste residuals and to complete tank bottom volume estimates.

A template of the 100-series 241-C Farm tanks was developed from tank construction drawings (BPF-73550, *Specifications for Construction of Composite Storage Tanks Bldg. No. 241 Hanford Engineer Works Project 9536*, Drawing D-3). The area and depth of waste and equipment in the tank bottom was estimated based on tank features and the dimensions of equipment and debris observed in the CCMS video. The waste contour information was then added to the template drawing to show waste remaining in the tank bottom. After completing the drawings, the AutoCAD Civil 3D software calculated a waste volume by integrating between the waste contour lines and the tank bottom profile

The estimated volume of waste on the tank bottom, calculated using AutoCAD Civil 3D was 44,000 L (11,770 gal). The waste volume consists of an estimated 35,830 L (9,470 gal) of solids piles and sand bars and 8,710 L (2,300 gal) in pooled liquids. The pool is entirely within the dish. Per RPP-23403, the actual volume is calculated, in cubic feet, by the following equation: Actual volume (ft^3) = 1.125*CCMS reading +0.53 ft^3.

2.3 Estimation of Waste Remaining on Tank Surfaces

The estimated volume of waste on the stiffener rings and tank walls after retrieval was 1,850 L (490 gal) and 5,330 L (1,410 gal), respectively (RPP-RPT-59004). Each of the four stiffener rings were assessed separately and found to have waste adhering to them as a thin layer with a depth from 0.15 cm (0.06 in.) to 10 cm (4 in.). The walls of tank C-102 appeared to also have a layer of waste of varying thickness. The volume of the waste on the tank wall was calculated in

[3] Honeywell Enraf is a product of Honeywell Process Solutions, Strahlenbergerstr. 110-112, 63067 Offenbach, Germany.

[4] AutoCAD and Civil 3D are trademarks of Autodesk, Inc., 111 McInnis Parkway, San Rafael, California.

sections between the stiffener rings. It was estimated that the layers of waste averaged from 0.15 cm (0.06 in.) to 5 cm (2 in.) thickness.

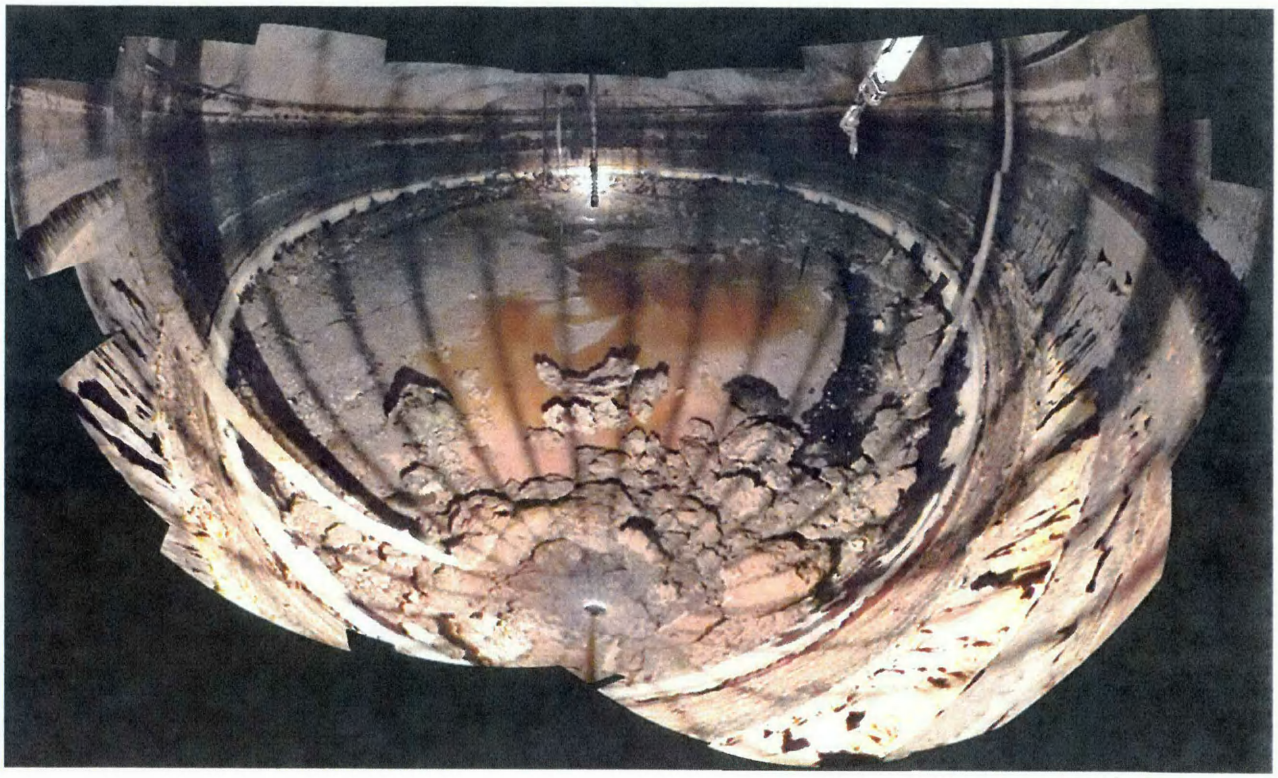
2.4 Estimation of Waste in Equipment

Per the DQO (RPP-23403), tank waste remaining in equipment is included in the waste volume; but the tank equipment is not included. In C-102, the only equipment with a significant volume of waste was the riser 9 sludge pump, which had an agglomeration of waste with an estimated volume of 1,160 L (307 gal). This estimate was made using the CCMS method discussed in section 2.2.

2.5 RESIDUAL WASTE VOLUME RESULTS

The total CCMS volume of post-retrieval residual waste in tank C-102 and the waste volumes associated with the various waste components are given in Table 2-1. The best estimate for the total post-retrieval waste volume in tank C-102 is 58,590 L (15,480 gal). The 95% UCL is 59,410 L (15,690 gal). Figure 2-1 shows a video composite of the residual waste in tank C-102.

Figure 2-1. Tank 241-C-102 Video Composite Looking across the Tank from Riser 3, Recorded July 1, 2015



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3. RESIDUAL TANK WASTE CHARACTERIZATION

This section describes the results of residual tank waste characterization for tank C-102. Presented are the average and upper bound estimates of residual waste inventory based on laboratory analysis of waste samples taken after waste retrieval actions were completed. The calculated inventories are used as input to estimate the potential risk to human health that arises from the residual waste. This risk assessment is discussed in Section 5.

3.1 SAMPLING AND ANALYSIS OF RESIDUAL WASTE

A tank sampling and analysis plan (RPP-PLAN-60550, *Sampling and Analysis Plan for Residual Waste Solids in Tank 241-C-102*) identified sample collection, laboratory analysis, quality assurance/quality control, and reporting requirements for the characterization of waste solids remaining in tank C-102 after completion of retrieval to support tank closure. The samples were analyzed according to the requirements in RPP-23403, *Single-Shell Tank Component Closure Data Quality Objectives,* and RPP-PLAN-23827, *Sampling and Analysis Plan for Single-Shell Tanks Component Closure*. RPP-PLAN-23827 identifies regulatory requirements for field sampling, laboratory analysis, and data reporting for residual waste samples to ensure appropriate data are collected to support SST closure activities.

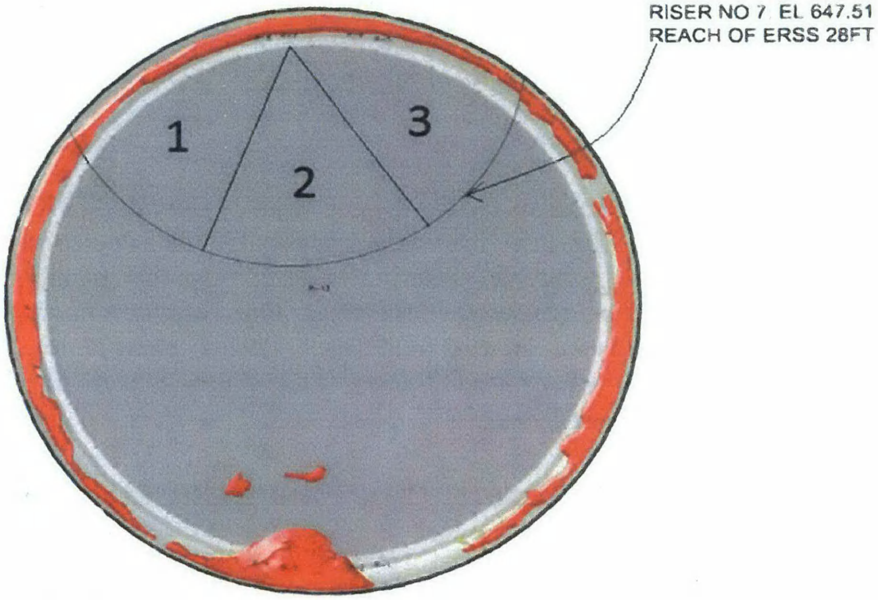
The residual solids in tank C-102 consist of two types of a loose, sand-like material near the center of the tank, with some larger chunks near the tank wall on the north side of the tank and the south side is made up of the harder material in a mound. Three samples were collected from three different zones on the north side of the tank and one sample from the south side of the tank using a Clamshell sampler and a single sample from the south side of the tank using a Solid Crusher break off pieces from the hardened mound using a Clamshell sampler to collect the created pieces.

Concurrence of the sampling design for tank C-102 was given by representatives from Ecology and the DOE-Office of River Protection (ORP) as documented by approval signatures in RPP-PLAN-60550.

3.2 SAMPLING AT SINGLE-SHELL TANK 241-C-102

A tank-specific sampling design for the tank C-102 post-retrieval sample event divided the remaining solids into two regions: one on the North side of the tank and one on the South side of the tank (RPP-PLAN-60550). The North side residual solids were made up primarily of a loose, sand-like material near the center of the tank, with some larger chunks near the tank wall. This region was divided into three areas and one sample was taken from each of these areas between March 15 and 16, 2016. The South side residual solids were made up of harder material in a mound. A sample was taken near the edge of this mound, directly under Riser 3, on February 10, 2016. One sample was collected from this region. The ERSS and a clamshell sampler, along with a solids crusher, were used to collect waste samples from the desired locations. Figures 3-1 and 3-2 shows the approximate sample locations. Figure 3-1 shows the approximate sample locations on the north region of tank C-102 collected from post retrieval.

Figure 3-1. Approximate Sample Locations in North Region of Tank C-102 Post-Retrieval



Source: RPP-PLAN-60550, *Sampling and Analysis Plan for Residual Waste Solids in Tank 241-C-102*

Figure 3-2. Approximate Sample Location in South Region of Tank C-102 Post-Retrieval

Source: RPP-PLAN-60550, *Sampling and Analysis Plan for Residual Waste Solids in Tank 241-C-102*

Once the sample from the north side was collected, it was judged in the field that sampling had reached the point of diminishing returns and sampling operations were discontinued. Representatives from Ecology and DOE-ORP agreed that further sampling was not necessary and that analysis results of the two collected samples may be used to calculate the mean concentrations and inventories for constituents of interest (RPP-RPT-59129).

3.3 SAMPLE ANALYSES

The samples listed in Table 3-1 were analyzed for the constituents identified in RPP-23403 and RPP-PLAN-23827 as defined by RPP-PLAN-60550. Analytical methods performed on the samples are identified in Table 3-2. The table also shows the corresponding analysis methods found in SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, where applicable. Sample analysis results are reported in RPP-RPT-59401, *Final Report for Tank 241-C-102 Waste Solid Samples in Support of Tank Closure*. Electronic data were also loaded into the Tank Waste Information Network System.

Table 3-1. Description of Tank 241-C-112 Post-Heel Retrieval Samples.

Sample Identification	Date Sampled	Date Received	Solid Weight (g)	Liquid Volume (mL)	Sample Description
C102-15-1	3/15/2016 14:05	3/15/2016 15:15	117.4	None	Partially full 240-mL bottle with white, brown, and gray solids. No organic layer visible.
C102-15-2	3/16/2016 10:15	3/16/2016 11:05	164.8	None	Partially full 240-mL bottle with brown solids. No organic layer visible.
C102-15-3	3/16/2016 13:45	3/16/2016 15:00	181.7	None	Partially full 240-mL bottle with brown solids. No organic layer visible.
C102-15-4	2/10/2016 09:50	2/10/2016 10:50	190.0	None	Full 240-mL bottle with light gray material. No organic layer visible.

Source: RPP-RPT-59401, *Final Report for Tank 241-C-102 Residual Solid Samples in Support of Tank Closure*.

Tentatively identified compounds (TIC) from organic analyses that met the TIC evaluation criteria in RPP-23403 and were reported as a TIC in RPP-RPT-59401 are listed in Table 3-3. These compounds are only semi-quantitative; therefore, inventories were not computed for TICs. The samples contained numerous alkanes and their alterations to ketones and acids.

3.4 CALCULATION OF RESIDUAL INVENTORY

The residual waste inventories were computed by following the Best-Basis Inventory (BBI) process as described in RPP-7625, *Guidelines for Updating Best-Basis Inventory*.
Two inventories were computed: an average inventory based on mean concentrations, density, volume and an upper bound inventory that is an estimate of an inventory at the 95% UCL. The inventories are discussed in the following sections.

3.4.1 Average Inventories

The average inventory for each waste constituent was calculated using the automated Best-Basis Inventory Maintenance (BBIM) tool (RPP-5945, *Best-Basis Inventory Maintenance Tool (BBIM): Database Description and User Guide*). This tool calculates the average inventory by finding the product of the mean concentration, the mean density, and the waste volume (i.e., inventory = concentration × density × volume). The calculations by the BBIM tool are summarized below. Table 3-3 identifies the residual solids compounds in tank C-102.

As described earlier, tank C-102 solids were sampled in tank C-102 after the heel retrieval which removed more than half of the amount of waste remaining after bulk retrieval. The mean concentrations were estimated as follows.

Table 3-2. Analytical Methods Used in Analysis of Post-Heel Retrieval Samples.

Analysis	SW-846 Reference Method[1]
Inorganic Analyses	
Bulk Density – Gravimetric	Not applicable
pH	9045
Weight percent water – Thermogravimetric Analysis	Not applicable
Cyanide – Spectrophotometric	9014
Mercury – Cold Vapor Atomic Absorption	7471B
Anions & Organic Acids – Ion Chromatography	9056A
Metals – Inductively Coupled Plasma/Atomic Emission Spectrometry	6010C
^{99}Tc – Inductively Coupled Plasma/Mass Spectrometry	3050B
^{126}Sn, Antimony – Inductively Coupled Plasma/Mass Spectrometry	3050B
Actinides – Inductively Coupled Plasma/Mass Spectrometry	3050B
Radiochemical Analyses	
Gamma Energy Analysis	Not applicable
$^{89/90}$Sr – Separation/Beta counting	Not applicable
^{14}C – Liquid Scintillation Counting	Not applicable
^{79}Se – Separation/Liquid Scintillation Counting	Not applicable
^{3}H – Liquid Scintillation Counting	Not applicable
^{63}Ni – Separation/Liquid Scintillation Counting	Not applicable
^{99}Tc – Separation/Liquid Scintillation Counting	Not applicable
^{129}I – Separation/Gamma Energy Analysis	Not applicable
^{241}Am – Separation/Alpha Energy Analysis	Not applicable
$^{239/240}$Pu, ^{238}Pu – Separation/Alpha Energy Analysis	Not applicable
^{241}Pu – Separation/Liquid Scintillation Counting	Not applicable
^{228}Th – Separation/Alpha Energy Analysis	Not applicable

Table 3-2. Analytical Methods Used in Analysis of Post-Heel Retrieval Samples.

Analysis	SW-846 Reference Method[1]
Organic Analyses	
Volatile Organic Compound – Gas Chromatography-Mass Spectrometry	8260C
Semivolatile Organic Compound – Gas Chromatography-Mass Spectrometry	8270D
Polychlorinated Biphenyl – Gas Chromatography-Electron Capture Detection	8082A

[1] "Not applicable" indicates that no corresponding analysis methods exist in SW-846.

Reference: SW-846, "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," 3rd Edition as amended.

The BBIM used equations from Variance Components (Searle et al. 1992) to estimate the mean concentration and density and the associated standard deviation for all constituents that had 50% or more of their reported values greater than the detection limit. These equations compute means by weighting results based on the variance components. Some constituents had concentrations that were below the detection limits. In these cases, the analytical method detection limits were used for calculating the mean concentrations. For a constituent with a majority of the analytical results below the analytical method detection limit, a simple average of the detection limits was calculated as if they were the analytical results for the constituent. Note that in accordance with BBI protocol, the relative standard deviations (RSD) for non-detected constituents were assumed to be "1" (RPP-7625).

Table 3-3. Tentatively Identified Compounds in Tank 241-C-102 Residual Solids.

Laboratory Sample Number	Tentatively Identified Compound	Result (µg/kg)	Retention Time (minutes)	CAS Number
S15T026504	2-Butanone, 3-methyl-	1.50E+03	3.29	563-80-4
S15T026653	2-Butanone, 3-methyl-	1.40E+03	3.29	563-80-4
S16T004703	2-Butanone, 3-methyl-	2.60E+03	3.29	563-80-4
S15T026653	Decane	1.40E+03	7.16	124-18-5
S15T026673	Decane	4.60E+01	15.62	124-18-5
S15T026677	Decane	1.50E+03	7.16	124-18-5
S15T026697	Decane	2.50E+02	15.63	124-18-5
S15T026649	Dodecane	7.40E+02	17.73	112-40-3
S15T026653	Dodecane	1.10E+04	9.35	112-40-3
S15T026673	Dodecane	2.30E+02	17.73	112-40-3
S15T026677	Dodecane	1.10E+04	9.35	112-40-3
S15T026697	Dodecane	5.60E+03	17.73	112-40-3
S15T026653	Pentadecane	1.80E+03	12.16	629-62-9
S15T026653	Tetradecane	6.90E+03	11.28	629-59-4
S15T026677	Tetradecane	5.00E+03	11.28	629-59-4
S15T026649	Tridecane	1.60E+03	18.79	629-50-5

Table 3-3. Tentatively Identified Compounds in Tank 241-C-102 Residual Solids.

Laboratory Sample Number	Tentatively Identified Compound	Result (µg/kg)	Retention Time (minutes)	CAS Number
S15T026653	Tridecane	1.30E+04	10.35	629-50-5
S15T026673	Tridecane	2.70E+02	18.79	629-50-5
S15T026677	Tridecane	1.30E+04	10.35	629-50-5
S15T026697	Tridecane	5.90E+03	18.80	629-50-5
S15T026649	Undecane	4.80E+02	16.69	1120-21-4
S15T026673	Undecane	4.40E+02	16.70	1120-21-4
S15T026697	Undecane	3.60E+03	16.71	1120-21-4
S15T026653	Unknown alkane	1.90E+03	10.06	--
S15T026653	Unknown Alkane2	1.70E+03	11.05	--
S15T026649	Unknown-1	2.40E+01	15.62	--
S15T026673	Unknown-1	2.90E+01	20.01	--
S15T026697	Unknown-1	8.00E+01	19.80	None
S15T026649	Unknown-2	8.00E+01	17.91	--
S15T026697	Unknown-2	1.50E+02	20.01	None
S15T026649	Unknown-3	1.10E+02	18.57	--
S15T026697	Unknown-3	4.20E+01	21.25	None
S15T026649	Unknown-4	7.90E+01	19.07	--
S15T026649	Unknown-5	7.70E+01	19.81	--
S15T026649	Unknown-6	1.20E+02	20.01	--

To calculate the average analyte inventories, the BBIM tool automatically used the mean concentrations from the samples taken after retrieval when available. The concentration means used by the BBIM tool to calculate the average inventories are provided in Appendix A, Table A-1. The BBIM also used the Searle, et al. (1992) equations to calculate the mean density and standard deviation for each set of samples. The density for the samples taken after retrieval was used for the inventory calculations.

As shown in Table 2-1, approximately 51,000 L (13,580 gal) of waste were left on the bottom of the tank floor which included solids and liquid on the tank floor and waste in the Riser 9 sludge pump (RPP-RPT-59004). The estimated volume of solids on the rings and side walls was 7,000 L (1,900 gal). The total residual volume used for inventory estimates is 58,000 L (15,480 gal) (51,000 L (13,580 gal) + 7,000 L (1,900 gal) = 58,000 L (15,480 gal). There are 7.481 gallons per cubic foot and 3.785 liters per gallon, therefore the solid volume is 59 kL used for the average inventory ([15,480 gal * 7.481 gal/ft^3 * 3.785 L/gal] * 1 kL/1000 L ≈ 59 kL).

3.4.2 Bounding Inventories

The 95% UCL inventory of each constituent was estimated based on a statistical method described in RPP-6924. This method is based on calculation of the average inventory (see Section 2) and a statistical uncertainty (quantified using a standard deviation) for the inventory. The standard deviation of the average inventory was calculated based on statistical uncertainties associated with the concentration, volume, and density measurements. Standard deviations for the mean concentrations (provided in Appendix B) and density were calculated using the BBIM tool. The standard deviation for waste volume was estimated as described below.

RPP-RPT-59004 provides estimates of post-retrieval residual waste volumes on the tank bottom, in the Riser 9 sludge pump, and on the tank wall and tank stiffener rings (see Table 3-3). The total waste volume was estimated at 58,600 L (15,480 gal). The upper bounding estimates for the waste volume components added up to 59,400 L (15,690 gal). The estimated error for the total volume may be represented as ± 0.105 ([15,690-15,480]/15,480). Using a factor of 2 for a two-sided 95% confidence level based on a normal distribution with a known variance, the RSD for the total waste volume was estimated to be 0.007 (0.014/2). This RSD was used to approximate the RSD associated with the solids volume.

The BBIM tool calculated the inventory RSD using the equation:

$$RSD^2(\hat{I}) \cong RSD^2(\bar{C}) + RSD^2(D) + RSD^2(\hat{V})$$

where $RSD^2(\hat{I})$ is the squared inventory RSD, $RSD^2(\bar{C})$ is the squared average concentration RSD, $RSD^2(D)$ is the squared average density RSD, and $RSD^2(\hat{V})$ is the squared total volume RSD.

According to RPP-6924, the Student's t-distribution (or any other probability distribution) is not applicable for determining a confidence interval for the mean inventory because there are no degrees of freedom associated with the volume measurement. The 95% UCL inventory was approximated by the equation:

$$UCL = \hat{I} + 2 \times \hat{I} \times RSD(\hat{I})$$

where $\hat{I}$ is the inventory estimate and $RSD(\hat{I})$ is the RSD of the inventory estimate. The factor "2 times the standard deviation of the estimate" in this equation is analogous to the factor "1.96 times the standard deviation of the mean" for a two-sided 95% confidence interval on the mean based on a normal distribution with a known variance (in accordance with the BBI process, which uses a two-sided 95% confidence interval for inventory). The 95% UCL inventories were calculated using the above equation and the average inventory estimates and associated RSDs that were calculated by the BBIM tool.

3.4.3 Evaluation of Sample Data Usability

Tank C-102 residual waste solids were sampled using the ERSS and clamshell sampler (with a solids crusher being used for the South sampling region), an accepted sampling method in the DQO (RPP-23403). A sampling design specific to the residual waste in tank C-102 was developed and documented in the sampling and analysis plan (RPP-PLAN-60550). Sample data collected by implementing this design can be used to estimate the mean concentration and data uncertainty for constituents of interest. The mean concentrations are shown in Table A-1. The solids RSDs in Table A-1 represent the uncertainty in the estimates due to sampling and analysis errors and due to the waste variability in the tank.

The 222-S Laboratory maintains a quality assurance (QA) program to ensure data quality. The waste samples were analyzed according to QA plans established by the program. In addition, the DQOs specify quality control criteria (e.g., standard recovery, matrix spike recovery, relative difference between duplicate analyses) that are specific to the closure project. The DQOs also provide direction for addressing data that do not meet the criteria. Results for most constituents satisfied the DQO criteria; those that did not meet the criteria were addressed according to the direction provided in the DQOs. Communications that were used to address data issues are included in the laboratory data report (RPP-RPT-59401).

Based on this assessment, it was concluded that the sampling and analysis met the DQO objectives and, therefore, the sample results are acceptable for uses discussed in the DQO, including risk assessment calculations.

3.4.4 Inventory Calculation Assumptions and Clarifications

The inventories were calculated in accordance with the BBI creation rules documented in RPP-7625. The calculation includes the following assumptions and clarifications:

- Inventories were generated only for constituents specified in the data quality objectives document (RPP-23403). Inventories for BBI analytes that are not included in RPP-23403 were not calculated. For the inventories of the BBI analytes, see RPP-RPT-57458, Revision 6.
- The inventories for ^{231}Pa are not reported, though it is a constituent specified in the data quality objectives document (RPP-23403). It was omitted because it was not measured above the analytical method detection limit and the detection limit was very high, which would have resulted in inventory values much greater than the expected total tank farms inventory for ^{231}Pa.
- Only data from the post-retrieval samples were used to calculate the inventories. Inventories of constituents not detected in the samples were calculated using the analytical method detection limits. Therefore, these specific inventories are considered conservative estimates.
- Concentration data are available only for solids on the bottom of the tank. Solids on the tank stiffener ring and the tank wall were not sampled and were assumed to have the same composition as the solids on the tank bottom.
- The volume estimate for the residual waste on the tank bottom includes liquids (RPP-RPT-59004). The separate solids and liquid volumes are not estimated; therefore, any liquid is included in the total residual solids volume in the tank.
- Thorium concentration was measured by inductively coupled plasma (ICP)/AES and ^{232}Th was measured by ICP/MS. Analyses by ICP/MS are generally more reliable at low concentration; therefore, the thorium inventory was calculated based on the ICP/MS results.
- Uranium concentration was based on concentrations of uranium isotopes detected by ICP/MS (^{233}U, ^{234}U, ^{235}U, ^{236}U, and ^{238}U).

- Uranium isotope ^{232}U was calculated from total uranium using isotopic distribution ratios.
- Plutonium isotopes (^{239}Pu, ^{240}Pu, and ^{242}Pu) were calculated from the $^{239/240}Pu$ analytical results, using the isotopic distribution ratios (RPP-8847, *Best-Basis Inventory Template Compositions of Common Tank Waste Layers*).
- Curium isotopes (^{243}Cm and ^{244}Cm) were calculated from the ^{241}Am analytical results, using the americium/curium isotopic distribution ratios (RPP-8847).
- In accordance with RPP-7625, the ^{137m}Ba inventory is equal to 0.944 times the ^{137}Cs inventory and the 90Y inventory is equal to the ^{90}Sr inventory.
- The laboratory was not able to measure xylene (m) and xylene (p) separately; therefore, these compounds were reported as xylene (m & p).
- As the name implies, TIC from organic analyses were not identified with certainty. In addition, measured concentrations for these compounds are only semi-quantitative. Therefore, inventories were not computed for TICs. Only TICs that met the TIC evaluation criteria in RPP-23403 and were reported as a TIC in RPP-RPT-59401 are in Appendix C, Table C-1. The samples contained numerous alkanes.
- Bulk density sample results had a range from 1.44 g/mL to 1.71 g/mL (RPP-RPT-59401) and a sample mean density of 1.60 g/mL.

3.5 INVENTORY ESTIMATES

The average and upper-bounding inventories for the residual solids are shown in Table 3-4. Note that the symbol "<" indicates the inventory was calculated based on the analytical method detection limit because the analyte was not detected in the samples. Radionuclide inventories are decay-corrected to July 1, 2015 (RPP-RPT-59129).

Table 3-4. Inventory Estimates for Selected Constituents in Tank C-102 Residual Solids.

Constituent	CAS Number	< Detection Limit	Average Inventory	Upper-Bounding Inventory	Inventory Units*
1,4-Dichlorobenzene	106-46-7	<	6.70E-03	2.01E-02	kg
125Sb	14234-35-6	<	1.09E+01	3.27E+01	Ci
126Sn	15832-50-5	<	5.23E-02	1.57E-01	Ci
129I	15046-84-1		1.60E-03	2.23E-03	Ci
137Cs	10045-97-3		6.35E+02	9.27E+02	Ci
137mBa	N/A		5.99E+02	8.75E+02	Ci
14C	14762-75-5		8.24E-03	1.03E-02	Ci
152Eu	14683-23-9	<	7.96E+00	2.39E+01	Ci
154Eu	15585-10-1	<	3.41E+00	1.02E+01	Ci
155Eu	14391-16-3	<	7.56E+00	2.27E+01	Ci
228Th	14274-82-9	<	2.37E-02	7.11E-02	Ci
230Th	14269-63-7	<	6.05E-01	1.82E+00	Ci

Table 3-4. Inventory Estimates for Selected Constituents in Tank C-102 Residual Solids.

Constituent	CAS Number	< Detection Limit	Average Inventory	Upper-Bounding Inventory	Inventory Units*
232Th	N/A		2.70E-03	5.04E-03	Ci
233U	13968-55-3		3.14E-01	5.58E-01	Ci
234U	13966-29-5		1.95E-01	3.81E-01	Ci
235U	15117-96-1		8.40E-03	1.63E-02	Ci
236U	13982-70-2		5.48E-03	1.05E-02	Ci
237Np	13994-20-2		4.03E-03	6.67E-03	Ci
238Pu	13981-16-3		5.57E-01	1.03E+00	Ci
238U	N/A		2.01E-01	3.90E-01	Ci
239Pu	15117-48-3		6.23E+01	1.27E+02	Ci
240Pu	14119-33-6		6.66E+00	1.36E+01	Ci
241Am	14596-10-2		1.69E+01	3.35E+01	Ci
241Pu	14119-32-5		2.67E+01	5.32E+01	Ci
242Cm	15510-73-3	<	8.72E-03	2.62E-02	Ci
242Pu	13982-10-0		9.18E-05	1.88E-04	Ci
243Cm	15757-87-6		2.54E-05	5.03E-05	Ci
244Cm	13981-15-2		4.84E-04	9.59E-04	Ci
2-Butanone	78-93-3	<	1.86E-03	5.58E-03	kg
3H	15086-10-9	<	1.07E-01	3.21E-01	Ci
4-Methyl-2-Pentanone	108-10-1	<	1.62E-03	4.86E-03	kg
60Co	10198-40-0	<	1.53E+00	0.00E+00	Ci
63Ni	13981-37-8		5.81E+02	8.99E+02	Ci
79Se	15758-45-9		2.34E-03	2.99E-03	Ci
90Sr	10098-97-2		5.54E+02	9.43E+02	Ci
90Y	10098-91-6		5.54E+02	9.43E+02	Ci
99Tc	14133-76-7		4.26E-01	7.27E-01	Ci
Acetate	71-50-1		1.09E+01	1.24E+01	kg
Acetone	67-64-1	<	2.08E-03	6.24E-03	kg
Ag	7440-22-4		5.57E+00	1.11E+01	kg
Al	7429-90-5		2.46E+04	2.68E+04	kg
Aroclors (Total PCB)	1336-36-3		2.22E-03	3.79E-03	kg
As	7440-38-2	<	1.43E+00	4.29E+00	kg
B	7440-42-8	<	1.91E-01	5.73E-01	kg

Table 3-4. Inventory Estimates for Selected Constituents in Tank C-102 Residual Solids.

Constituent	CAS Number	< Detection Limit	Average Inventory	Upper-Bounding Inventory	Inventory Units*
Ba	7440-39-3		3.55E-01	5.69E-01	kg
Be	7440-41-7		1.32E-01	1.68E-01	kg
Benzo(a)pyrene	50-32-8	<	1.18E-02	3.54E-02	kg
Bi	7440-69-9	<	1.81E+00	0.00E+00	kg
Bis(2-ethylhexyl)phthalate	117-81-7		3.51E-01	5.69E-01	kg
Br	24959-67-9	<	2.23E+00	0.00E+00	kg
Butylbenzylphthalate	85-68-7		9.46E-02	1.24E-01	kg
Ca	7440-70-2		1.57E+01	2.01E+01	kg
Cd	7440-43-9		1.10E-01	1.28E-01	kg
Ce	7440-45-1	<	2.39E+00	7.17E+00	kg
Cl	16887-00-6		8.31E+00	1.00E+01	kg
CN	57-12-5		4.14E+00	5.34E+00	kg
Co	7440-48-4	<	9.89E-02	2.97E-01	kg
Cr	7440-47-3		1.10E+01	2.34E+01	kg
Cu	7440-50-8		8.18E+00	1.20E+01	kg
Dibenz[a,h]anthracene	N/A	<	1.25E-02	3.75E-02	kg
Diethylphthalate	84-66-2	<	2.12E-02	0.00E+00	kg
Di-n-butylphthalate	84-74-2		6.23E-02	0.00E+00	kg
Diphenyl amine	122-39-4	<	1.00E-02	0.00E+00	kg
Eu	7440-53-1	<	9.55E-02	2.87E-01	kg
F	16984-48-8		2.85E+02	4.67E+02	kg
Fe	7439-89-6		1.62E+02	2.55E+02	kg
Formate	12311-97-6		1.11E+01	1.51E+01	kg
Free OH	N/A		6.95E-01	1.42E+00	kg
Glycolate	666-14-8	<	2.38E+00	7.14E+00	kg
Hexachlorobenzene	118-74-1	<	8.93E-03	0.00E+00	kg
Hg	7439-97-6		4.16E-01	1.08E+00	kg
K	7440-09-7		1.07E+01	1.51E+01	kg
La	7439-91-0	<	9.55E-02	2.87E-01	kg
Li	7439-93-2	<	1.15E-01	3.45E-01	kg
Mg	7439-95-4		6.60E+00	7.41E+00	kg
Mn	7439-96-5		4.72E+01	1.20E+02	kg

Table 3-4. Inventory Estimates for Selected Constituents in Tank C-102 Residual Solids.

Constituent	CAS Number	< Detection Limit	Average Inventory	Upper-Bounding Inventory	Inventory Units*
Mo	7439-98-7		2.29E-01	2.66E-01	kg
Na	7440-23-5		3.10E+03	3.76E+03	kg
Nb	7440-03-1	<	5.73E-01	1.72E+00	kg
Nd	7440-00-8	<	1.43E+00	4.29E+00	kg
NH3	7664-41-7		2.36E-01	2.83E-01	kg
Ni	7440-02-0		1.17E+02	1.78E+02	kg
N-Nitrosodimethylamine	62-75-9	<	9.23E-03	0.00E+00	kg
NO2	14797-65-0		2.78E+02	3.28E+02	kg
NO3	14797-55-8		5.47E+02	6.57E+02	kg
Oxalate	338-70-5		1.49E+01	1.72E+01	kg
Pb	7439-92-1		4.21E+00	6.39E+00	kg
Pd	7440-05-3	<	1.15E+00	3.45E+00	kg
Pentachlorophenol	87-86-5	<	1.13E-02	3.39E-02	kg
Phenol	108-95-2	<	1.06E-02	3.18E-02	kg
PO4	14265-44-2		7.02E+02	1.36E+03	kg
Pr	7440-10-0	<	2.48E+00	7.44E+00	kg
Rb	7440-17-7	<	5.44E+00	1.63E+01	kg
Rh	7440-16-6	<	1.15E+00	3.45E+00	kg
Ru	7440-18-8	<	4.77E-01	1.43E+00	kg
Sb	7440-36-0	<	1.72E+00	5.16E+00	kg
Se	7782-49-2	<	2.86E+00	8.58E+00	kg
Si	7440-21-3		8.47E+01	9.51E+01	kg
Sm	7440-19-9		3.60E+00	5.85E+00	kg
Sn	7440-31-5		1.97E+00	3.06E+00	kg
SO4	14808-79-8		5.58E+01	6.08E+01	kg
Sr	7440-24-6		1.05E+00	1.67E+00	kg
Ta	7440-25-7	<	4.77E-01	1.43E+00	kg
Te	13494-80-9		8.96E-01	9.93E-01	kg
Th	7440-29-1		2.46E+01	4.58E+01	kg
Ti	7440-32-6		2.68E+00	4.14E+00	kg
Tl	7440-28-0	<	1.43E+00	4.29E+00	kg
Toluene	108-88-3	<	7.60E-05	2.28E-04	kg

Table 3-4. Inventory Estimates for Selected Constituents in Tank C-102 Residual Solids.

Constituent	CAS Number	< Detection Limit	Average Inventory	Upper-Bounding Inventory	Inventory Units*
Tributyl phosphate	126-73-8		4.28E-01	7.51E-01	kg
Trichloroethene	79-01-6	<	1.15E-04	3.45E-04	kg
U	7440-61-1		6.02E+02	1.15E+03	kg
V	7440-62-2		5.52E-01	9.05E-01	kg
W	7440-33-7	<	1.53E+00	4.59E+00	kg
Xylene (m & p)	108-28-3M	<	1.59E-04	4.77E-04	kg
Xylene (o)	95-47-6	<	9.67E-05	2.90E-04	kg
Xylenes (total)	1330-20-7	<	3.85E-05	1.16E-04	kg
Y	7440-65-5	<	1.91E-01	5.73E-01	kg
Zn	7440-66-6		5.36E+00	6.59E+00	kg
Zr	7440-67-7		3.92E+01	7.64E+01	kg

*Radionuclide concentrations are decay corrected to July 1, 2015.

CAS = Chemical Abstract Services

N/A = not applicable

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4. RETRIEVAL SYSTEM PERFORMANCE

This section discusses the tank C-102 waste retrieval system performance in terms of residual waste, retrieval duration, and water use. In addition, this section compares the achieved waste retrieval results against predicted performance. The residual tank volume at the end of retrieval was described in Section 2.

The DOE-ORP has deployed two technologies at tank C-102: (1) modified sluicing technology via Extended Reach Sluicers using supernate from double-shell tank (DST) AN-101, and (2) High Pressure Water. Sluicing operations started on April 27, 2014 with an initial waste volume of ~1,200,000L (~316,000 gal), and ended on April 6, 2015 when operations reached the limits of sluicing technology. The majority of the waste in C-102 consisted of a soft brown sludge.

The supernatant liquor was the primary carrier fluid during this period recirculated from tank AN-101 to tank C-102. A total of ~1,036,000 L (~274,000 gal) of waste was removed by the first retrieval technology, leaving ~158,570 L (~42,000 gal) in the tank. The second retrieval technology (high-pressure water) was used beginning on April 7, 2015, running concurrently with sluicing, and reached the limits of technology on May 8, 2015. The residual waste solids volume remaining in the tank were estimated at 59,470 L (15,500 gal) (RPP-RPT-59004).

4.1 WASTE RETRIEVAL PROCESS DESCRIPTION

The sluicing system in tank C-102 consisted of two ERSSs used to remove the waste from tank C-102. Supernate from tank 241-AN-101 (AN-101) was used as the sluicing fluid to mobilize the waste in tank C-102. The resulting slurry was pumped from tank C-102 to tank AN-101. The solids settled in tank AN-101 and the supernate was recycled for sluicing. After the more readily retrievable solids were removed from the tank, the high-pressure water nozzles, attached to the ERSS, were used to break up larger pieces of hard waste that could not be broken up by the ERSSs alone. Once broken up, this waste was removed from the tank by sluicing with the ERSSs.

The two ERSSs were located at opposite sides of the tank and were each fitted with two high-pressure water nozzles located on either side of the sluicing nozzle. A variable-depth slurry pump was located in the middle of the tank. The slurry pump had a 3 m (10 ft) adjustment range and could be extended to the bottom of the tank. The adjustable height slurry pump was lowered as the waste retrieval progressed and the waste level receded. Two closed-circuit video cameras were installed to support sluicing. The ERSSs, slurry pump, supernatant pump, and a motor-operated valve to control the supernatant flow rate were controlled from a control trailer near the tank.

A slurry distributor installed in tank AN-101 distributed the waste sludge as it was received from tank C-102. As retrieval progressed, the adjustable height horizontal distributor was raised to keep it above the settled solids from tank C-102. The supernatant pump in tank AN-101 was used to pump liquid to the ERSSs in tank C-102. The pump inlet elevation was adjusted as needed to keep it at least 107 cm (42 in.) above the bottom of the slurry distributor.

Tank C-102 is the third tank to use the ERSS for retrieval of tank waste (after tanks 241-C-101 and 241-C-112). The ERSS is different from a standard sluicer in that it has a boom, as well as a mast, which can be used to place the sluicer nozzle closer to the waste and increase the effectiveness of sluicing in breaking up solid waste in the tank. The ERSS boom is designed to extend and retract and elevate approximately 90° along the vertical. The mast rotates ±180°, providing a side-to-side motion to the boom. These operations can be manipulated to bring the nozzle much closer to the waste in the tank than is possible with the fixed-elevation standard sluicer. The nozzle on the ERSS is capable of continuous rotation 360° in both the elevation and transverse functions (Figure 1-1).

Each ERSS in tank C-102 is also equipped with two high-pressure water nozzles, the second deployed technology, that deliver water at ~4,800 psi to further break up hard waste material. Tank C-102 is the second tank to use these water nozzles with the ERSS (tank 241-C-101 was the first). The ERSSs used for tanks 241-C-112 and 241-C-101 retrieval were long reach ERSSs with booms that could extend and retract with a range of 4.6 to 8.5 m (15 to 28 ft). Due to the starting waste level in tank C-102, it was not possible to install long reach ERSSs without retrieving some of the waste first. Prior to the start of tank C-102 retrieval, two short reach ERSSs with a boom extension range of 2.4 to 4.6 m (8 to 15 ft) were installed. After sufficient space was cleared, both short reach ERSSs were removed and a long reach ERSS was installed in riser #7. Later, a new short reach ERSS was installed in riser #2.

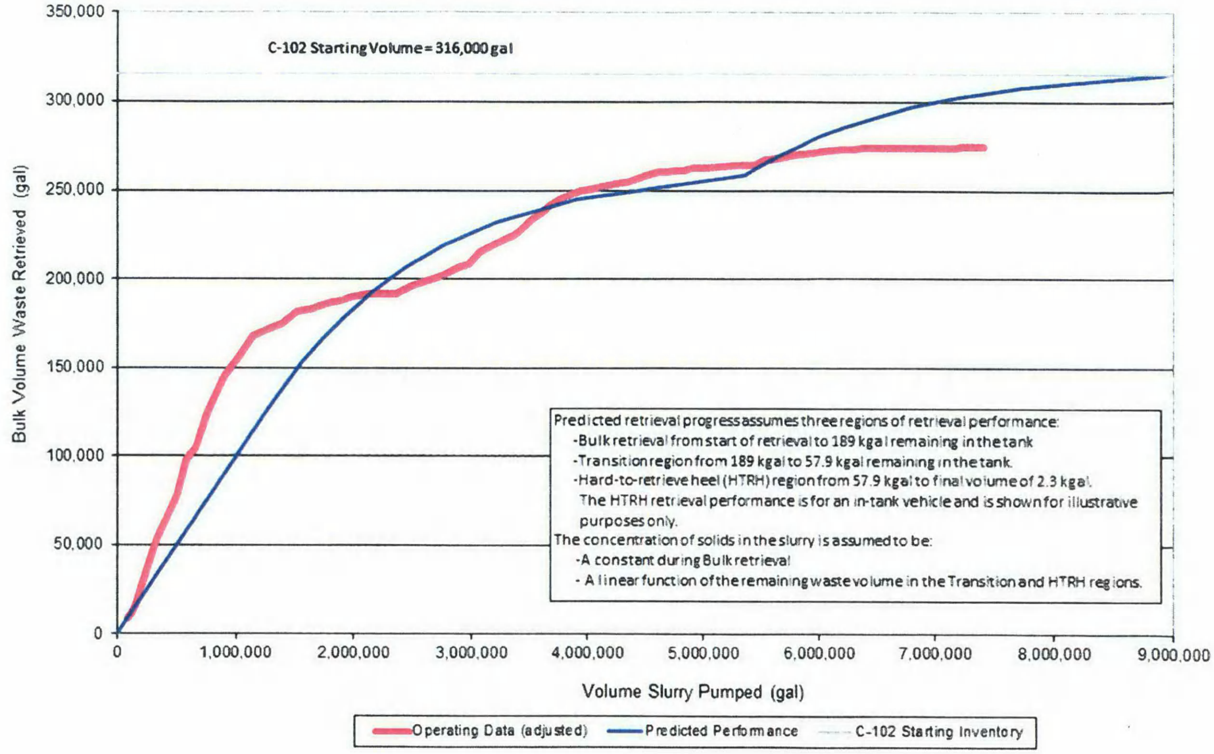
4.2 RETRIEVAL SYSTEM PERFORMANCE

Retrieval operations were performed during 85 operating days (155 shifts) starting on April 27, 2014 and ending on May 8, 2015. The majority of the waste in tank C-102 consisted of a soft brown sludge that could be readily mobilized by the ERSSs and pumped from the tank. The exceptions were a hard mound of waste under riser 2 and a hard layer of waste around the tank walls. Retrieval proceeded rapidly until the slurry pump screen was lowered to ~1.1 m (~3.5 ft) above the bottom of the tank. At that point, a hard surface was encountered which caused difficulties in lowering the slurry pump.

Retrieval system performance was tracked by trending the net waste volume increase in the receiver tank AN-101 after accounting for water additions; this is shown as the Operating Data (Adjusted) line in Figure 4-1. This running volume balance does not account for solids dissolution or liquid evaporation. As the volume of waste material received by tank AN-101 approaches the starting waste volume of tank C-102, the estimate of the volume remaining in tank C-102 (using the arithmetic difference between these two volumes) becomes increasingly sensitive to uncertainties in the starting waste volume estimate and cumulative measurement uncertainties. The running volume balance and other information were used to generate an estimate of the actual volume of waste retrieved during modified sluicing of tank C-102.

As shown by the slope of the line in Figure 4-1, the retrieval rate for tank C-102 was high and relatively constant through about the first 635,949 L (168,000 gal) of waste retrieved (~53%) which was reached on July 22, 2014. The retrieval rate slowed to a lower rate and then remained relatively constant through ~719,228 L (190,000 gal) retrieved by July 30, 2014. The slowed retrieval rate was partly due to sluicing the harder solids near the tank wall. Another factor was the difficulty with lowering the slurry pump, due to a hard layer of material (possibly agglomerated waste or concrete) beneath the pump, which limited how far the liquid pool in tank C-102 could be pumped down.

Figure 4-1. Tank 241-C-102 Waste Retrieval Progress.



Up to this point, sluicing was conducted with the riser 7 ERSS. It was determined that attempting to undermine the hard layer obstruction by sluicing with the riser 2 ERSS might be more effective than continued sluicing with the riser 7 ERSS as the riser 2 ERSS could be used to more effectively clear out material from the riser 2 mound. Despite a hydraulic leak (see report RPP-CALC-57513, *C-102 Riser-002 ERSS Stress during Operation and Support Addition Assessment*) the remaining nozzle elevation and transverse functions were used to sluice riser 2 mound and undermining of the hard layer obstruction under the pump screen was performed between August 8 and August 17.

During this time, hot water additions were also performed in an attempt to soften the hard waste under the pump and on the tank walls. A test with hot water sluicing (52°C [125°F]) was performed on August 3, 2014 to evaluate the effectiveness of hot water on the waste under the pump and the hard waste near the walls. Approximately 21,955 L (5,800 gal) of hot water were used in sluicing under the pump and in sluicing some chunks of hard waste near the wall. Approximately 18,548 L (4,900 gal) of hot water were flushed through the slurry pump and allowed to soak for about 5 hours before it was pumped out. No significant impact from hot water was seen. On August 12, 2014, an additional test with hot water sluicing was performed using the ERSS in riser 7 to evaluate the effectiveness of hot water on the hard waste on the tank walls. Hot water (52 C [125°F]) was added through the ERSS at about 52 gpm for 40 minutes (12:07 to12:47 pm). The sluice stream was aimed at a single location on the hard waste on the wall. Again, no significant impact from hot water was seen, based on an evaluation of the video of the sluicing location.

The retrieval rate increased with the use of the riser 2 ERSS; the riser 7 ERSS had been used exclusively up to that point. Some progress was made on breaking down the riser 2 mound, and sluicing/undermining the hard layer obstruction enabled the slurry pump to be lowered several additional inches. Retrieval shut down on August 17, 2014 for ERSS replacement; at this point the pump was at a total extension of 2.2 m (7.3 ft). The riser 2 ERSS was removed on September 11, 2014. Riser 2 was tested with a Go/No Go gauge on October 4, 2014. The test was unsuccessful, and it was decided to remove the riser 7 ERSS and replace that ERSS with a long reach ERSS instead. The riser 7 ERSS was removed on October 16, 2014.

The retrieval rate increased more sharply with the installation of the long reach ERSS in riser 7, which was installed on October 17, 2014 at ~787,365 L (208,000 gal) of waste retrieved. Retrieval operations resumed briefly on October 29, 2014; operations were shut down due to issues with the speed control for the tank AN-101 supernate pump. Retrieval resumed again on November 10, 2014. Prior to resuming sluicing, the slurry pump was lowered to an extension of 2.4 m (8 ft). The supernate that was sitting in the tank from August through October may have helped to soften the hard waste enough to lower the pump.

The retrieval rate remained steady until December 17, 2014, through ~927,425 L (245,000 gal) of waste retrieved. During retrieval operations on December 12 and 13, 2014, the slurry pump was lowered to a total extension of 2.8 m (9.5 ft), putting the bottom of the pump screen within 15 cm (6 in.) of the bottom of the tank. Based on an evaluation of the in-tank video, it appeared that at least part of the hard surface that had blocked the pump screen still remained in the tank, but it had either been worn away or pushed aside during sluicing and no longer posed as an obstruction for the pump.

From 927,425 L (245,000 gal) of waste retrieved and onwards, the retrieval rate slowed. At that point the majority of the fines had been washed from the tank, leaving hard waste that was resistant to sluicing and material in the size range of sand to small gravel that could be moved by the ERSSs but not picked up by the pump. During operations in January 2015, the slurry pump was lowered to a total extension of ~2.97 m (9.75 ft), within a few inches of the bottom of the tank, by January 9, 2015 with ~987,922 L (261,000 gal) of waste retrieved. Some retrieval progress was achieved due to the lowering of the slurry pump, but progress was limited to the area of influence of the riser 7 ERSS and a total of 999,348 L (264,000 gal) of waste was retrieved by January 25, 2015.

A short reach ERSS was installed in riser 2 on February 19, 2015. When retrieval operations resumed in mid-March, the riser 2 ERSS was able to break up material that the riser 7 ERSS could not reach. Operations alternated between using the riser 7 ERSS and the riser 2 ERSS. By March 21, 2015 1,033,417 L (273,000 gal) of waste were retrieved. During this period retrieval rates improved slightly, then plateaued as the remaining waste consisted of hard chunks around the perimeter of the tank that were very slow to break up under sluicing, and sand to gravel-sized material in the center of the tank that could be pushed around by the ERSSs but not pumped out by the slurry pump.

The use of high-pressure water, the second retrieval technology, beginning on April 8, 2015 was able to break off small pieces of the hard chunks of waste while creating a small amount of fines, but did not improve the waste retrieval rate. Only 1,510 L (400 gal) of additional waste retrieval was achieved using 47,320 L (12,500 gal) of high-pressure water and 2,082,000 L (550,000 gal) of supernate for sluicing.

Table 4-1 shows the waste retrieval efficiency from March 21 to May 8, 2015. The bulk solids concentration in the slurry remained below 0.6 vol. percent for the operating periods from March 21 through May 8 even with the use of high-pressure water.

Table 4-1. Waste Retrieval Efficiency (March 21 to May 8, 2015).

Operating Period Number	Operating Period	Bulk Volume Solids Retrieved, L (gal*)	Slurry Pumped, L (gal)	Slurry Operating Hours	High-Pressure Water Operating Hours	Solids in Slurry, vol%
1	3/21/2015	2396 (633)	486,762 (128,589)	22.95	—	0.49%
2	3/22/2015	310 (82)	346,149 (91,443)	16.43	—	0.09%
3	4/3/2015	1775 (469)	312,580 (82,575)	14.22	—	0.57%
4	4/4/2015	0 (0)	478,355 (126,368)	22.32	—	0.29%
	4/5/2015	2706 (715)	460,794 (121,729)	22.47	—	

Table 4-1. Waste Retrieval Efficiency (March 21 to May 8, 2015).

Operating Period Number	Operating Period	Bulk Volume Solids Retrieved, L (gal*)	Slurry Pumped, L (gal)	Slurry Operating Hours	High-Pressure Water Operating Hours	Solids in Slurry, vol%
5	4/6/2015	0 (0)	413896 (109,340)	19.92	—	0.04%
	4/8/2015 to 4/10/2015	0 (0)	592,787 (156,598)	27.97	5.92	
	4/11/2015	0 (0)	485,736 (128,318)	22.77	—	
	4/12/2015	0 (0)	491,165 (129,752)	23.27	—	
	4/13/2015	0 (0)	51,212 (13,529)	2.70	—	
	4/15/2015	230 (0)	176,627 (46,660)	8.48	—	
6	4/16/2015	0 (0)	100,745 (26,614)	4.43	11.62	0.26%
	4/17/2015 04:50 to 10:45	0 (0)	64,606 (17,067)	2.78	2.07	
	4/17/2015 10:45 to 4/18/2015 04:15	628 (166)	72,884 (19,254)	3.40	9.23	
7	4/18/2015 04:15 to 5/8/2015 11:17	0 (0)	130,623 (34,507)	6.48	4.22	0.00%

*0 gal retrieved includes periods with net volume increase in tank 241-C-102 due to the addition of liquid (water or supernate) and periods with net volume decrease in tank 241-C-102 due only to the reduction of liquid volume in the tank.

Because the estimate of waste residual remaining in tank C-102 following the deployment of modified sluicing and high pressure water nozzle technologies exceeded the Consent Decree volume requirement, DOE submitted to Ecology a request to forego implementation of a third technology that would otherwise be required by the terms of the Consent Decree (RPP-RPT-58676). In the Practicability Request, DOE evaluated a set of candidate technologies for hard heel waste retrieval that were reviewed and documented in RPP-RPT-44139. From this evaluation, it was concluded that none of the existing retrieval technologies is a viable candidate as an immediately available third technology in tank C-102. None of the existing retrieval technologies have a reasonable expectation of successful retrieval of much additional waste. The use of a new chemical retrieval using another chemical agent is the most viable choice for a third retrieval technology. However, the time frame of such a development and the actual effectiveness of such a chemical process are uncertain.

4.3 WASTE RETRIEVAL EFFICIENCY

The preliminary estimate for the tank C-102 modified sluicing rate indicated that it would require 3,406,870,605 L (9,000,000 gal) of slurry to transfer the estimated 1,200,000 L (316,000 gal) of tank C-102 waste to tank AN-101. The rate at which the waste slurry pumped from tank C-102 to tank AN-101 was at a lower rate. However, when the campaign had transferred ~90% of tank C-102 waste, over 26,497,882 L (7,000,000 gal) of slurry had been used and the technology was concluded.

4.4 RETRIEVAL DURATION

The duration of pre-retrieval modified sluicing for tank C-102 using a modified sluicing platform was estimated to be less than 30 days, based on a progression of waste per gallon of slurry and the expected slurry per shift. Retrieval operations were performed, removing over 90% of the corrected waste volume during 85 operating days over two campaigns starting on April 27, 2014 and ending on May 8, 2015; the tank C-102 retrieval consisted of a sluicing operation over a 377-calendar-day period (1 year 12 days).

A pump down was performed on May 8 to close out the last operating period for high-pressure water. After the pump down was completed, ~151,416 L (40,000 gal) of supernate was pumped to tank C-102 to perform a liquid displacement measurement of the waste remaining in the tank. Following the liquid displacement, rinsing of the residual tank C-102 waste was performed on May 9, with ~189,270 L (50,000 gal) of water.

4.5 CONCLUSION

Based on the information contained in Section 4.2 above, DOE-ORP concluded that waste retrieval operations were performed to the limits of the sluicing technology and high-pressure water retrieval technology (RPP-RPT-58281). At that time the residual waste volume in tank C-102 was estimate (RPP-CALC-60351) to be 76,460 L (20,200 gal).

A final tank C-102 waste volume evaluation, based largely on the tank video CCMS estimate for the waste volume in C-101 as of July 1, 2015, estimated a 59,400 L (15,690 gal)95% UCL for the residual volume of 59,400 L (15,690 gal), which is greater than the goal of 10,200 L (2,690 gal) after deploying the technologies. The RPP-RPT-58676, *Practicability Evaluation Request to Forego a Third Retrieval Technology for Tank 241-C-102*, concluded that the two waste retrieval technologies deployed at tank C-102 had each been deployed to its respective limits of technology, and that implementation of a third technology was not practicable as that term is used in Appendix C, Part 1, of the Consent Decree in Washington v. DOE, Case No. CV-08-5085-RMP (E.D. WA. October 25, 2010).

5. POST-RETRIEVAL SINGLE-SHELL TANK 241-C-102 RISK ASSESSMENT

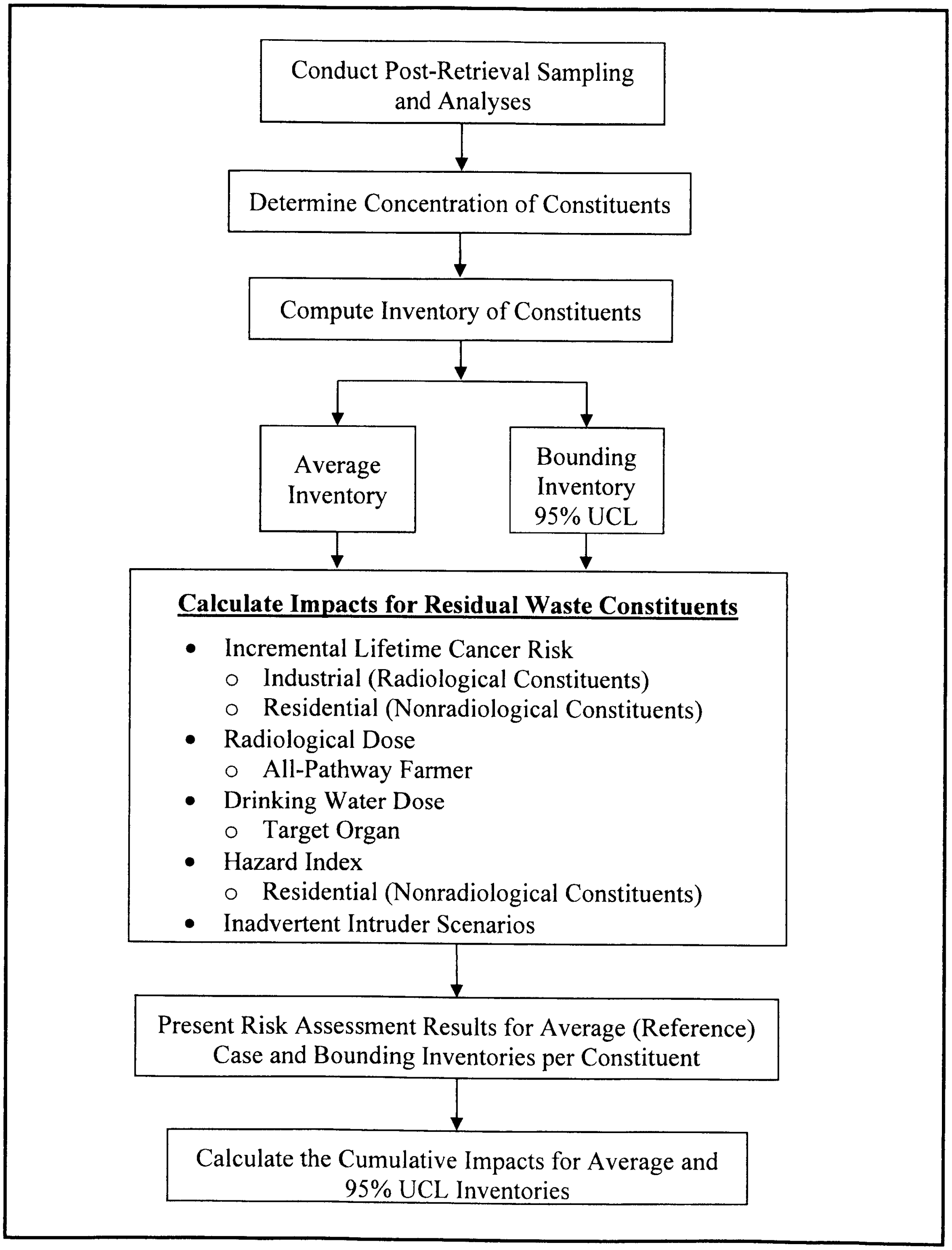
The potential impacts to human health posed by the residual waste in tank C-102 were evaluated using the methodology documented in DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site*. Figure 5-1 provides a schematic of the process used for the tank C-102 risk assessment, and this methodology is described in detail in Chapter 3 of DOE/ORP-2005-01. The SST performance assessment (PA) methodology represents the current approach being used to support the assessment of long-term impacts to human health from tank residuals left in individual SSTs in RDRs. Decisions on final closure of tank C-102, all other SSTs, and ancillary facilities and equipment within Waste Management Area (WMA) C will be supported by a site-specific PA as outlined in Appendix I of the HFFACO. That single PA will evaluate whether closure conditions at Waste Management Area (WMA) C will be protective of human health and the environment for all contaminants of concern, both radiological and non-radiological. The DOE intends that the PA will document by reference relevant performance requirements defined by *Resource Conservation and Recovery Act of 1976*, RCW 70.105, "Federal Water Pollution Control Act" (Clean Water Act), *Safe Drinking Water Act of 1974*, and the *Atomic Energy Act of 1954*, as well as any other performance requirements that might be Applicable or Relevant and Appropriate Requirements under *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*.

The inventory used in this tank C-102 risk assessment was derived from post-retrieval residual inventory samples (see Section 3). A comparison of post-retrieval inventory to the inventory used in DOE/ORP-2005-01 is provided in Appendix C for information purposes. The inventory used in DOE/ORP-2005-01 is based on RPP-RPT-23412, *Hanford Tank Waste Operations Simulator Model Data Package for the Development Run for the Refined Target Case*. The post-retrieval inventory used in this RDR provides a more accurate representation of tank residuals than RPP-RPT-23412 and will be incorporated in the WMA C PA.

Results of the potential impacts to human health were calculated using the average and 95% UCL inventories. Results show that for the groundwater pathway, the effects associated with tank C-102 range from four orders of magnitude below to slightly below the current incremental lifetime cancer risk (ILCR) performance objectives (1.0E-06 to 1.0E-4) for radioactive analytes, and one to 11 orders of magnitude below the ILCR performance objectives (1.0E-05) for non-radioactive analytes. The hazard indices for the tank C-102 groundwater pathway are two to three orders of magnitude below the performance objective (1.0).

The inadvertent intruder scenarios, the well driller (acute exposure), at 100 years after closure was below the performance objective of 500 mrem. The rural pasture and commercial farm (chronic exposure), at 100 years after closure were below the 100 mrem/yr performance objectives. For the suburban garden (a sensitivity case) inadvertent intruder scenario, at 100 years after closure, the effects associated with tank C-102 exceeded the 100 mrem/yr performance objective for chronic exposure. Details of these results are provided in Sections 5.2 through 5.4.

Figure 5-1. Single-Shell Tank 241-C-102 Residual Waste Inventory and Risk Assessment Process.



UCL = upper confidence level

This section also provides additional risk management information related to concentrations of constituents remaining in waste residuals within tank C-102 compared against the WAC 173-340 cleanup standards. The soil cleanup standards evaluated are developed for direct contact exposures and for groundwater protection. Selected constituent concentrations estimated for the average and 95% UCL inventories of tank residuals are specifically compared against soil direct contact cleanup levels for unrestricted land use (Method B), soil direct contact cleanup levels for industrial land use (Method C), and soil cleanup levels protective of groundwater using the fixed parameter three-phase partitioning model given in WAC 173-340-747, "Deriving Soil Concentrations for Groundwater Protection," subsection (4), "Fixed parameter three-phase partitioning model." Results of these comparisons are found in Section 5.5.1.

Section 5.5 also includes a discussion of the appropriateness of comparisons for constituent concentrations remaining in waste residuals within tank C-102 against cleanup standards protective of ecological risk found in WAC 173-340. Because footnotes in tables containing the cleanup standards protective of ecological concerns indicate these standards are not intended to be used for evaluation of sludges or wastes, specific comparisons of concentrations of constituents remaining in waste residuals within tank C-102 against the WAC 173-340 cleanup standards related to ecosystem risk are not provided.

5.1 CONSTITUENTS EVALUATED

Following retrieval, the residual waste was sampled and analyzed. This risk assessment is based on the analytical results from the post-retrieval sample (Section 3).

Analytical data for tank C-102 were collected and analyzed as defined by the closure DQOs. The post-retrieval samples were analyzed for 119 constituents (i.e., radionuclides, volatile organic compounds, semi-volatile organic compounds, polychlorinated biphenyls, and inorganics [including metals and conventional parameters]) in accordance with approved 222-S Laboratory procedures based on U.S. Environmental Protection Agency approved methods. However, analytes flagged as a non-detect were evaluated at one-half the detection limit in accordance with EPA/540/1-89/002, *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final*. Table 5-1 presents a complete listing of the analytes evaluated, whether the analyte was detected, and whether a cancer potency factor (also called a cancer slope factor), dose factor, or reference dose is published for that analyte.

Table 5-1. List of Analytes and Available Toxicity Information.

Isotope/ CAS	Analyte[a]	Detect	Available Toxicity Information[b]	Isotope/ CAS	Analyte[a]	Detect	Available Toxicity Information[b]
241Am	Americium-241		DFR/CPF	84-66-2	Diethyl phthalate[c]	U	RfD
125Sb	Antimony-125[c]	U	DFR/CPF	84-74-2	Di-n-butylphthalate[c]		RfD
137mBa	Barium-137m[c]		--	7440-53-1	Europium	U	--
14C	Carbon-14		DFR/CPF	16984-48-8	Fluoride		RfD
137Cs	Cesium-137 + Daughters		DFR/CPF	12311-97-6	Formate+A2		--
60Co	Cobalt-60	U	DFR/CPF	Glycolate	Glycolate C2H3O3	U	--
242Cm	Curium-242	U	DFR/CPF	118-74-1	Hexachlorobenzene[c]	U	RfD/CPF
243Cm	Curium-243		DFR/CPF	OHDEMAND	Hydroxide OH		--
244Cm	Curium-244		DFR/CPF	7439-89-6	Iron		RfD
152Eu	Europium-152	U	DFR/CPF	7439-91-0	Lanthanum	U	--
154Eu	Europium-154	U	DFR/CPF	7439-92-1	Lead[c]		--
155Eu	Europium-155	U	DFR/CPF	7439-93-2	Lithium	U	RfD
129I	Iodine-129		DFR/CPF	7439-95-4	Magnesium		--
237Np	Neptunium-237 + D		DFR/CPF	7439-96-5	Manganese		RfD
63Ni	Nickel-63[c]		DFR/CPF	7439-97-6	Mercury[c]		RfD
238Pu	Plutonium-238		DFR/CPF	7439-98-7	Molybdenum		RfD
239Pu	Plutonium-239		DFR/CPF	108-38-3	m-Xylene	U	RfD
240Pu	Plutonium-240		DFR/CPF	108-38-3	m-Xylene	U	RfD
241Pu	Plutonium-241 + D		DFR/CPF	122-39-4	N, N-Diphenylamine[c]	U	RfD
242Pu	Plutonium-242		DFR/CPF	7440-00-8	Neodymium	U	--
79Se	Selenium-79[c]		DFR/CPF	7440-02-0	Nickel[c]		RfD
90Sr	Strontium-90 + D		DFR/CPF	7440-03-1	Niobium	U	--

Table 5-1. List of Analytes and Available Toxicity Information.

Isotope/ CAS	Analyte[a]	Detect	Available Toxicity Information[b]	Isotope/ CAS	Analyte[a]	Detect	Available Toxicity Information[b]
99Tc	Technetium-99		DFR/CPF	14797-55-8	Nitrate		RfD
228Th	Thorium-228 + D	U	DFR/CPF	14797-65-0	Nitrite		RfD
230Th	Thorium-230	U	DFR/CPF	62-75-9	N-Nitroso-N, N-dimethylamine[c]	U	RfD/CPF
232Th	Thorium-232		DFR/CPF	338-70-5	Oxalate		--
126Sn	Tin-126	U	DFR/CPF	95-47-6	o-Xylene	U	RfD
3H	Tritium	U	DFR/CPF	7440-05-3	Palladium	U	--
233U	Uranium-233		DFR/CPF	87-86-5	Pentachlorophenol[c]	U	RfD/CPF
234U	Uranium-234		DFR/CPF	108-95-2	Phenol[c]	U	RfD
235U	Uranium-235 + D		DFR/CPF	14265-44-2	Phosphate		--
236U	Uranium-236		DFR/CPF	1336-36-3	Polychlorinated Biphenyls[c]		CPF
238U	Uranium-238 + D		DFR/CPF	7440-09-7	Potassium		--
90Y	Yttrium-90		--	7440-10-0	Praseodymium	U	--
79-01-6	1, 1, 2-Trichloroethylene	U	RfD/CPF	7440-16-6	Rhodium	U	--
106-46-7	1, 4-Dichlorobenzene	U	RfD/CPF	7440-17-7	Rubidium	U	--
78-93-3	2-Butanone(MEK)	U	RfD	7440-18-8	Ruthenium	U	--
108-10-1	4-Methyl-2-pentanone (MIBK)	U	RfD	7440-19-9	Samarium		--
71-50-1	Acetate		--	7782-49-2	Selenium[c]	U	RfD
7429-90-5	Aluminum		RfD	7440-21-3	Silicon		--
7664-41-7	Ammonia		RfD	7440-22-4	Silver[c]		RfD

Table 5-1. List of Analytes and Available Toxicity Information.

Isotope/ CAS	Analyte[a]	Detect	Available Toxicity Information[b]	Isotope/ CAS	Analyte[a]	Detect	Available Toxicity Information[b]
7440-36-0	Antimony[c]	U	RfD	7440-23-5	Sodium		--
7440-38-2	Arsenic[c]	U	RfD/CPF	7440-24-6	Strontium		RfD
7440-39-3	Barium[c]		RfD	14808-79-8	Sulfate		--
50-32-8	Benzo[a]pyrene[c]	U	CPF	7440-25-7	Tantalum	U	--
7440-41-7	Beryllium[c]		RfD/CPF	13494-80-9	Tellurium		--
7440-69-9	Bismuth	U	--	7440-28-0	Thallium[c]	U	RfD
7440-42-8	Boron	U	RfD	7440-29-1	Thorium		--
24959-67-9	Bromide	U	--	7440-31-5	Tin		RfD
85-68-7	Butylbenzylphthalate[c]		RfD	7440-32-6	Titanium		--
7440-43-9	Cadmium[c]		RfD/CPF	108-88-3	Toluene[c]	U	RfD
7440-70-2	Calcium		--	126-73-8	Tributyl phosphate		RfD/CPF
7440-45-1	Cerium	U	RfD	7440-33-7	Tungsten	U	--
16887-00-6	Chloride		--	7440-61-1	Uranium		--
7440-47-3	Chromium, Total[c]		--	7440-62-2	Vanadium		RfD

Table 5-1. List of Analytes and Available Toxicity Information.

Isotope/ CAS	Analyte[a]	Detect	Available Toxicity Information[b]	Isotope/ CAS	Analyte[a]	Detect	Available Toxicity Information[b]
7440-48-4	Cobalt	U	RfD/CPF	1330-20-7	Xylenes	U	RfD
7440-50-8	Copper		RfD	7440-65-5	Yttrium	U	--
57-12-5	Cyanide[c]		RfD	7440-66-6	Zinc		RfD
117-81-7	Di (2-ethylhexyl) phthalate (DEHP)		RfD/CPF	7440-67-7	Zirconium		--
53-70-3	Dibenz[a, h]anthracene[c]	U	CPF				

a. RPP-RPT-59129, *Tank 241-C-102 Residual Waste Inventory Estimates for Component Closure Risk Assessment.*

b. HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments.*

c. Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List."

Gray shaded area indicates non-detect for this analyte.

-- = No available toxicity value (dose factor, reference dose, or cancer potency factor)

CAS = Chemical Abstracts Service

CPF = Cancer potency factor

DFR = dose factor

RfD = Reference dose

U = Analyte not detected in residual wastes

5.2 RESULTS FOR INDIVIDUAL CONTAMINANTS FOR POST-RETRIEVAL SINGLE-SHELL TANK 241-C-102

Table 5-2 identifies the main contributors to the ILCR (industrial and residential scenarios), groundwater dose (all-pathways farmer scenario), and drinking water dose for radiological components of the residual waste remaining in tank C-102. Table 5-3 identifies the primary hazardous chemicals that contribute to ILCR and the Hazard Quotient. These results are provided for the average residual waste inventory for tank C-102. A more complete listing of all analytes for the same average inventory is provided in Tables D-1 and D-2 of Appendix D. A similar set of tables based on the 95% UCL inventory is provided in Tables D-3 and D-4 of Appendix D. In each of these tables, the following columns are provided.

a. **Analyte Name**

b. **Detected in Residual Wastes** is an indicator as to whether an analyte was detected in the laboratory.

c. **Inventory** as shown here for non-detects is calculated at one-half the detection limit.

d. **WMA C Fenceline Concentration** is the maximum modeled concentration for a constituent at the WMA C fenceline over the modeling period. In the methodology used in DOE/ORP-2005-01, this concentration was estimated using cross-sectional modeling of vadose zone and groundwater flow and transport. In some cases, individual analytes may not have a corresponding concentration at the fenceline because short-lived radionuclides will decay away before the contaminant can arrive at the WMA C fenceline. Relatively immobile contaminants (i.e., K_d greater than 0.6 mg/L) will also result in a zero concentration at the fenceline as they will not reach the fenceline within 10,000 years (based on assumptions and transport modeling approach used).

e. **Peak Year** is the year in which the simulation estimates that peak concentration for a given analyte arrives at the fenceline.

f. $\mathbf{K_d}$ is the mobility factor used in the groundwater modeling for the analyte. The smaller the K_d, the more mobile the contaminant; if the K_d is zero, the contaminant moves with the groundwater.

g. **Half-life** is the duration in years for a radionuclide to decay to half its activity. Organic compounds were assumed not to decay (radionuclides only).

h. **Incremental Lifetime Cancer Risk** (groundwater) is described in HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments*, for the industrial and residential exposure scenarios [including WAC 173-340, Method B (residential)].

i. **Radiological Dose** is the estimated drinking water dose for the all-pathways farmer exposure scenario (radionuclides only).

j. **Radiological Dose – Beta/Photon** is the drinking water dose from beta/photon emitting radionuclides using equivalent dose (radionuclides only).

k. **Hazard Quotient** (groundwater) – Hazard quotients calculated for residential and industrial scenarios described in HNF-SD-WM-TI-707.

5.3 CUMULATIVE ANALYSIS RESULTS FOR SINGLE-SHELL TANK 241-C-102 AND WASTE MANAGEMENT AREA C

The cumulative analysis (i.e., sum of the risk metrics) for tank C-102 residual average and 95% UCL risk levels were calculated and are provided in this section.

Average Inventory—best estimate of the residual waste inventory computed using mean sample concentrations, mean sample density, and best estimate of the residual volume.

95% UCL Inventory—considered the bounding inventory. The 95% UCL of the average inventory was calculated based on uncertainties associated with the concentration, volume, and density (for solids) measurements (see Section 3).

The impacts for the groundwater pathway associated with each residual waste inventory are evaluated with a variety of performance metrics. The ILCRs are evaluated for radiological analytes using the average and 95% UCL inventories and industrial and residential exposure scenarios. The ILCR and hazard indices are examined for the same inventories using a residential exposure scenario.

Radiological doses using the same two inventories are also evaluated for an all-pathways farmer and a drinking water only exposure scenario. Estimated concentration levels of some selected analytes are also provided and compared against current maximum concentration levels.

A comparison of impacts from the average and the 95% UCL inventories and current performance metrics for ILCR, hazard indices, and maximum concentration limits are summarized in Table 5-4.

Results of a comparison done on Table 5-4 are summarized in Table 5-5.

5.4 INADVERTENT INTRUDER

The DOE recognizes that an inadvertent intruder may be onsite and not be discovered until after exposure has occurred. The radiological dose to an inadvertent intruder is therefore estimated as a part of this risk assessment.

The scenarios considered in this assessment for radiological doses from inadvertent intrusions included: 1) a well driller scenario that was used as a reference case for acute exposure in the SST PA and 2) a rural pasture scenario that was used as a reference case for chronic exposure in the SST PA. This assessment of doses from inadvertent intrusions also evaluated chronic exposure scenarios that included: 1) a suburban gardener scenario and 2) a commercial farmer scenario that were used as sensitivity cases for chronic exposure in the SST PA.

A summary of doses calculated for each of the intruder scenarios for the average and 95% UCL inventories remaining at tank C-102 at 100 years and 500 years after closure for tank C-102 are provided in Table 5-6. A summary of doses calculated for each of the intruder scenarios for the average and 95% UCL inventories at 100-year intervals between 100 and 1,000 years after closure for tank C-102 are provided in Table 5-7. Tables and plots of doses related to individual radioactive analytes are provided in Tables D-5 through D-8 and Figures D-1 through D-4 in Appendix D.

Table 5-2. Estimated Maximum Incremental Lifetime Cancer Risk/Radiological Dose During the Modeling Period for Primary Radionuclides Related to Average Residual Waste Inventory in SST 241-C-102.

Analyte	Above Detection Limits in Residual Waste	Inventory (Ci)	WMA C Fenceline Concentration (pCi/L)	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Lifetime Cancer Risk		Radiological Dose (mrem/yr) All-Pathways Farmer Scenario[b]	Radiological Dose - Beta/Photon (mrem/yr) Drinking Water Only Scenario[b]
							Industrial	Residential		
^{14}C	Yes	8.24E-03	1.27E-02	9,781	0.00E+00	5.73E+03	9.86E-11	7.13E-10	6.15E-05	2.54E-05
^{99}Tc	Yes	4.26E-01	1.70E+00	10,461	0.00E+00	2.11E+05	2.34E-08	5.71E-07	2.98E-03	7.56E-03
^{129}I	Yes	1.60E-03	<1.00E-03	12,032	2.00E-01	1.57E+07	NE	NE	NE	NE
^{234}U	Yes	1.95E-01	0.00E+00	DNA	6.00E-01	2.46E+05	NE	NE	NE	N/A
^{235}U	Yes	8.40E-03	0.00E+00	DNA	6.00E-01	7.04E+08	NE	NE	NE	N/A
^{236}U	Yes	5.48E-03	0.00E+00	DNA	6.00E-01	2.34E+07	NE	NE	NE	N/A
^{238}U	Yes	2.01E-01	0.00E+00	DNA	6.00E-01	4.47E+09	NE	NE	NE	N/A
Performance Objective[d]							**1-0E-6 to 1.0E-4[e]**	**1-0E-6 to 1.0E-4[e]**	**25[f]**	**4[g]**

a. PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide*, Rev. 1, for the basis for the Kd values listed for the radionuclides.

b. All exposure scenarios are described in HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments*.

c. Simulation predicted contaminant arrives at the fence line, but at a concentration (<0.001 pCi/L) that is much below the minimum detection limit for standard analytical methods.

d. Performance objectives apply to the cumulative (i.e., all contaminants) for the entire waste management area.

e. EPA 540-R-012-13, *Radiation Risk Assessment At CERCLA Sites: Q & A, Directive 9200.4-40*.

f. DOE O 435.1, Radioactive Waste Management.

g. 65 FR 76708, "National Primary Drinking Water Regulations; Radionuclides; Final Rule."

Shaded cell indicates non-detects in sludge or supernate, and the inventory used in the risk assessment is calculated at one-half the minimum detection limit.

DNA = did not arrive at fenceline within the modeling period

NE = constituent analyzed, but this risk metric was not calculated because the analyte was predicted to have a concentration less than 0.001 pCi/L, which is well below the ability of standard laboratory methods to detect it

Table 5-3. Estimated Maximum Value for Incremental Lifetime Cancer Risk and Hazard Quotient for Selected Non-Radiological Analytes Related to Average Residual Waste Inventory in SST 241-C-102.

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	WMA C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[a]	Incremental Lifetime Cancer Risk Scenarios (Groundwater)[b]	Hazard Quotient (Groundwater)[b]
						WAC 173-340 Method B	
Chromium, Total[c]	Yes	1.10E+01	4.52E-02	10,481	0.00E+00	No CPF	No Rfd
Fluoride	Yes	2.85E+02	1.17E+00	10,481	0.00E+00	No CPF	1.22E-03
Nitrate	Yes	5.47E+02	2.25E+00	10,481	0.00E+00	No CPF	8.77E-05
Nitrite	Yes	2.78E+02	1.14E+00	10,481	0.00E+00	No CPF	7.13E-04
Uranium	Yes	6.02E+02	0.00E+00	DNA	6.00E-01	NE	NE
Performance Objective[d]						**1.0E-06[e]**	**1.0[f]**

a. PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide*, Rev. 1, for the basis for the Kd values listed for chromium and nitrate. The Kd values listed for the organic chemical compounds are determined from the chemicals' organic carbon/water partitioning coefficient and an estimate of 0.03% for the Hanford Site sediments fraction of organic content (PNNL-13895, Rev. 1, page 11, paragraph 3).

b. All exposure scenarios are described in HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments*.

c. Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List." Total Cr is assumed to be Chromium(III) insoluble salts.

d. Single Analyte Performance objectives apply to entire waste management area, not just a single component of the waste management area.

e. WAC 173-340-705, "Use of Method B," subsection (2)(c)(ii).

f. WAC 173-340-705 (2)(c)(i).

DNA = did not arrive at fenceline within the modeling period

NE = constituent analyzed, but this risk metric was not calculated because the analyte was predicted to have a concentration less than 0.001 µg/L, which is well below the ability of standard laboratory methods to detect it

No CPF = no cancer potency factor available

No Rfd = no reference dose available

Table 5-4. Comparison of Cumulative Incremental Lifetime Cancer Risk, Hazard Index, Radionuclide Dose, and Groundwater Concentration at Peak Waste Management Area C Fenceline for Average and 95% Upper Confidence Level Residual Waste Inventories in Single-Shell Tank 241-C-102.

Metric[a]	Industrial Receptor		Residential Receptor		Performance Objective[b]
	Average Inventory	95% Upper Confidence Level Inventory	Average Inventory	95% Upper Confidence Level Inventory	
Incremental Lifetime Cancer Risk from Radioactive Analytes (unitless)					
Total without non-detects[c]	2.35E-08	4.01E-08	5.72E-07	9.75E-07	1.0E-06 to 1.0E-4[e]
Total with non-detects[d]	2.35E-08	4.01E-08	5.72E-07	9.75E-07	
Incremental Lifetime Cancer Risk from Non-Radioactive Analytes (unitless)					
Total without non-detects[c]	4.46E-17	7.83E-17	3.12E-16	5.47E-16	1.0E-5[f]
Total with non-detects[d]	4.74E-09	7.71E-12	6.58E-07	1.60E-11	
Hazard Index (unitless)					
Total without non-detects[c]	3.21E-04	4.68E-04	2.18E-03	3.19E-03	1.0[f]
Total with non-detects[d]	3.45E-04	4.69E-04	6.00E-03	3.19E-03	
Radiological Dose (mrem/yr)	**All-Pathways**		**Drinking Water**		**Performance Objective[b]**
	Average Inventory	**95% Upper Confidence Level Inventory**	**Average Inventory**	**95% Upper Confidence Level Inventory**	
Total without non-detects[c]	3.04E-03	5.16E-03	7.58E-03	1.29E-02	25[g] and 4[h] mrem
Total with non-detects[d]	3.04E-03	5.16E-03	7.58E-03	1.29E-02	

Table 5-4. Comparison of Cumulative Incremental Lifetime Cancer Risk, Hazard Index, Radionuclide Dose, and Groundwater Concentration at Peak Waste Management Area C Fenceline for Average and 95% Upper Confidence Level Residual Waste Inventories in Single-Shell Tank 241-C-102.

Waste Management Area C Fenceline Concentration, d				
Analyte	**Detected In Residual Wastes**	**Average Inventory**	**95% Upper Confidence Level Inventory**	**Maximum Concentration Limit**
Technetium-99	Yes	1.70E+00	2.90E+00	900 pCi/L
Iodine-129	Yes	<1 00E-03	<1 00E-03	1 pCi/L
Carbon-14	Yes	1.27E-02	1.59E-02	2,000 pCi/L
Chromium, Total[i]	Yes	4.52E-02	9.61E-02	100 μg/L

a. Incremental lifetime cancer risks of radioactive analytes were evaluated using industrial and residential land use scenarios described in HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments.* Incremental lifetime cancer risks and hazard indices for non-radiological analytes were evaluated using WAC 173-340-705, "Use of Method B," subsection (4) "Multiple hazardous substances or pathways" (residential).

b. Performance objectives apply to entire waste management area, not just a single component of the waste management area.

c. If detected, fenceline concentration is based on an inventory that is calculated from actual laboratory results. Analytes with a fenceline concentration of less than either 0.001 pCi/L (radioactive) or 0.001 μg/L (nonradioactive), which is a value that is well below the minimum detection limit for standard analytical methods, are reported as less than 1.00E-03 pCi/L or μg/L.

d. If not detected, fenceline concentration is based on an inventory that is calculated at half the detection limits of analytical results. Concentrations that are less than either 0.001 pCi/L (radioactive) or 0.001 μg/L (nonradioactive), which is a value that is well below the minimum detection limit for standard analytical methods, are reported as less than 1.00E-03 pCi/L or μg/L.

e. EPA 540-R-012-13, *Radiation Risk Assessment At CERCLA Sites: Q & A, Directive 9200.4-40.*

f. WAC 173-340-705 (4).

g. DOE O 435.1, *Radioactive Waste Management.*

h. 65 FR 76708, "National Primary Drinking Water Regulations; Radionuclides, Final Rule."

i. Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List." Total Cr is assumed to be Chromium(III) insoluble salts.

Gray shaded cells are nondetects and the inventory used in the risk assessment is calculated at one-half the minimum detection limit.

Table 5-5. Comparison Summary of Cumulative Incremental Lifetime Cancer Risk, Hazard Index, Radiological Dose, and Groundwater Concentration at Peak Waste Management Area C Fenceline for Average and 95% Upper Confidence Level Residual Waste Inventories in SST 241-C-102.

Performance Metric	Comparison(s) with Performance Objective
Incremental Lifetime Cancer Risk (ILCR) for Radioactive Analytes (1.0E-06 to 1.0E-04 ILCR)	• Estimated ILCRs for all radionuclides range from four orders of magnitude below the performance objective to slightly below the performance objective range of 1.0E-06 to 1.0E-04 ILCR.
ILCR for Non-Radiological Analytes (1.0E-05 ILCR)	• Estimated ILCRs for all non-radionuclides are one to 11 orders of magnitude lower than the upper end of the performance objective of 1.0E-05 ILCR.
Hazard Indices (1.0)	• Estimated hazard indices for all analytes are two to three orders of magnitude below performance objective of 1.0.
Radiological Dose • 25 mrem/yr All-Pathways • 4 mrem/yr Drinking Water Only	• Estimated doses for all radionuclides are between ○ Four orders of magnitude below the performance objective for the all-pathways dose of 25 mrem/yr ○ Three orders of magnitude below the performance objective for drinking water dose of 4 mrem/yr.
Maximum Concentration Limits of Key Analytes • ^{99}Tc – 900 pCi/L • ^{129}I – 1 pCi/L • ^{14}C – 2,000 pCi/L • Cr – 100 µg/L	• Estimated concentrations for ^{99}Tc are two orders of magnitude below 900 pCi/L maximum contaminant level. • Predicted concentration levels of other constituents of potential concern (e.g., ^{129}I, ^{14}C, and Cr) are significantly lower than their respective maximum contaminant levels.

Table 5-6. Comparison of Intruder Doses at 100 and 500 Years after Closure from Residual Waste for SST 241-C-102.

Years after Closure[a]	Inventory	SST PA Reference Case		SST PA Sensitivity Cases	
		Well Driller[b] (mrem)	Rural Pasture[c] (mrem/yr)	Suburban Garden[c] (mrem/yr)	Commercial Farm[3] (mrem/yr)
100	Average	9.7	6	91	0.060
	95% UCL	17	10	162	0.11
500	Average	4.5	1.3	28	0.036
	95% UCL	9.1	2.6	57	0.072

a. Site closure is assumed to occur on January 1, 2032.

b. Performance Objective (Acute Exposure) – 500 mrem.

c. Performance Objective (Chronic Exposure) – 100 mrem/yr.

PA = performance assessment SST = single-shell tank UCL = upper confidence level

A review of detailed results and plots in Appendix D (Figures D-1 through D-4 and Tables D-5 through D-8) resulted in observations about key analytes for inadvertent intruder impacts as given in Table 5-8.

At 100 years after closure (Tables 5-6 and 5-7), doses for the well driller scenario were estimated to be ~2% and 3% of the 500 mrem acute exposure performance objective for the average and the 95% UCL inventories, respectively. At 100 years after closure, doses with the rural pasture scenario were estimated to be ~6% and 10% of the 100 mrem/yr chronic exposure performance objective for the average and 95% UCL inventories, respectively. However, doses resulting from chronic exposure in the suburban garden scenario were ~91% and 160% of the 100 mrem/yr chronic exposure performance objective for the average and 95% UCL inventories, respectively (Table 5-6). Doses resulting from the commercial farmer were well below (e.g., 0.06% and 0.1%) the 100 mrem/yr chronic exposure performance objective for the average and 95% UCL inventories, respectively (Table 5-6).

By 500 years after closure (Tables 5-6 and 5-7), the estimated doses for the well driller scenario for the average and 95% UCL inventories was ~1% and 2% of the acute exposure performance objective of 500 mrem, respectively. At 500 years after closure, doses for all inadvertent intruder scenarios used to evaluate the doses from chronic exposure were well below the chronic exposure performance objective of 100 mrem/yr. The highest estimated dose at 500 yrs after closure was for the suburban gardener scenario using the 95% UCL inventory, which yielded a dose that was estimated to be ~57% of the 100 mrem/yr performance objective (Table 5-6).

5.5 COMPARISON OF TANK RESIDUALS WITH MODEL TOXICS CONTROL ACT SOIL CLEANUP LEVELS

This section provides additional risk management information related to concentrations of constituents remaining in waste residuals within tank C-102 compared against the Model Toxics Control Act (MTCA) (RCW 70.105D, "Hazardous Waste Cleanup — Model Toxics Control Act") WAC 173-340 cleanup standards. In this section, specific comparisons are made between the concentrations of constituents remaining in tank C-102 against the MTCA cleanup standards for soil direct contact unrestricted land use (Method B), industrial land use (Method C), and soil concentrations protective of groundwater using the fixed parameter three-phase partitioning model given in WAC 173-340-747(4).

Per WAC 173-340-740, "Unrestricted Land Use Soil Cleanup Standards," for soil cleanup levels based on human exposure via direct contact or other exposure pathways where contact with the soil is required to complete the pathway, the point of compliance shall be established in the soils throughout the site from the ground surface to 4.6 m (15 ft) below the ground surface. Under a closure configuration, waste residuals left in tank C-102 and other SSTs in WMA C would be expected to be below 4.6 m (15 ft) below ground surface.

Implicit in the use of the fixed parameter three-phase partitioning model given in WAC 173-340-747 is the assumption that constituents of interest are found in soils and are immediately available to be leached by infiltrating precipitation. Under a closure configuration, constituents associated with waste residuals left in tank C-102 and other SSTs in WMA C would be contained within a grout-filled tank, a steel tank liner, and an underlying concrete pad below the liner and would not be immediately available for leaching by infiltrating water.

Table 5-7. Potential Future Impact from Inadvertent Intrusion into Residual Waste for Average and 95% Upper Confidence Level Inventories.

Years After Closure[1]	100	200	300	400	500	600	700	800	900	1,000
Inadvertent Intrusion Acute Dose[2] (mrem) – Well Driller Scenario										
Average Inventory	9.7	5.3	4.7	4.6	4.5	4.4	4.3	4.3	4.2	4.2
95% Upper Confidence Level Inventory	17	10	9.6	9.3	9.1	9.0	8.8	8.7	8.6	8.5
Inadvertent Intrusion Chronic Dose[3] (mrem/yr) – Rural Pasture Scenario										
Average Inventory	6	1.8	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.2
95% Upper Confidence Level Inventory	10	3.4	2.8	2.6	2.6	2.5	2.5	2.5	2.4	2.4
Inadvertent Intrusion Chronic Dose[3] (mrem/yr) – Suburban Gardener Scenario										
Average Inventory	91	35	30	29	28	28	27	27	26	26
95% Upper Confidence Level Inventory	162	70	60	58	57	56	55	55	54	53
Inadvertent Intrusion Chronic Dose[3] (mrem/yr) – Commercial Farm Scenario										
Average Inventory	6.0E-02	4.0E-02	3.7E-02	3.6E-02	3.6E-02	3.5E-02	3.4E-02	3.4E-02	3.3E-02	3.3E-02
95% Upper Confidence Level Inventory	0.11	8.1E-02	7.6E-02	7.4E-02	7.2E-02	7.1E-02	7.0E-02	6.9E-02	6.8E-02	6.8E-02

[1] Site closure is assumed to occur on January 1, 2032.

[2] Performance Objective (Acute Exposure) – 500 mrem.

[3] Performance Objective (Chronic Exposure) – 100 mrem/yr.

Table 5-8. Impact Results of Key Analytes for an Inadvertent Intruder.

Inadvertent Intrusion Scenario	Key Radionuclides			
	^{137}Cs	^{90}Sr	^{239}Pu	^{241}Am
Well Driller	Primary contributor to dose up to ~110 yrs post-closure	Tertiary contributor to dose post-closure	Primary contributor to dose after ~110 yrs post-closure	Secondary contributor to dose ~180 yrs post-closure
Rural Pasture	Secondary contributor to dose betwee~110 to ~180 yrs post-closure	Primary contributor to dose up to ~1500 yrs post-closure; secondary contributor to dose ~150 to ~200 yrs post closure	Primary contributor to dose ~150 yrs post-closure	Secondary contributor to dose ~220 post-closure
Suburban Gardener	Tertiary contributor to dose after ~120 yrs post-closure	Primary contributor to dose up to ~120 yrs post-closure	Primary contributor to dose ~150 yrs post-closure	Secondary contributor to dose between ~120 and ~200 yrs after closure; primary contributor to dose ~200 yrs post-closure
Commercial Farm	Secondary contributor to dose up to ~150 yrs post-closure	Tertiary contributor to dose post-closure	Primary contributor to dose after ~100 years post-closure	Secondary contributor to dose after150 yrs post-closure

5.5.1 WAC 173-340 Direct Contact and Soil Concentrations Protective of Groundwater

Table 5-9 contains the average and 95% UCL concentrations of detected constituents estimated in residual waste for tank C-102 on a mass basis for comparison against WAC 173-340 cleanup levels for soil direct contact unrestricted land use (Method B), industrial land use (Method C), and soil concentration protective of groundwater. Table 5-9 also provides Hanford Site-specific 90th percentile background concentrations, and identifies analytes that are dangerous waste constituents per WAC 173-303-9905, "Dangerous Waste Constituents List". A more detailed list of background concentrations and references is provided in Table D-11 of Appendix D.

Ratios of the average and 95% UCL concentrations to cleanup levels for soil direct contact (Method B and Method C) and soil concentrations protective of groundwater are provided in Tables 5-10 and 5-11, respectively. The ratios are obtained by dividing the analyte concentration by the soil direct contact cleanup level or the soil concentration protective of groundwater. The level of exceedance (ratio) corresponds to the level of residual waste concentration remaining in tank C-102 above or below the cleanup level. A level of exceedance greater than 1 corresponds to a residual waste concentration greater than the cleanup level. Tables 5-10 and 5-11 also identify analytes that are dangerous waste constituents per WAC 173-303-9905 and analytes with concentrations that exceed 90th percentile background concentrations. Expanded lists of non-radioactive analytes that were not detected are provided in Tables D-10 and D-11 in Appendix D.

The results for waste residual concentrations estimated for the average residual waste inventory from detected analytes are briefly summarized below.

- For direct contact under an unrestricted land use scenario, only aluminum and uranium are above the cleanup levels. Aluminum had a concentration more than 3 times the soil cleanup level.
- For direct contact under an industrial land use scenario, no analytes exceeded their respective cleanup levels.
- For soil concentrations protective of groundwater, cadmium, cyanide, fluoride, mercury, nitrate, nitrite, silver, tributyl phosphate, and uranium are all above the concentration predicted by the MTCA fixed parameter three-phase model. Cadmium, cyanide, mercury, and silver are listed as dangerous constituents per WAC 173-303-9905.

The results for waste residual concentrations estimated in the 95% UCL residual waste inventory are briefly summarized below.

- For direct contact under an unrestricted land use scenario, aluminum, cyanide, fluoride, and uranium are above the cleanup levels. Cyanide is listed as a dangerous constituent per WAC 173-303-9905.
- For direct contact under an industrial land use scenario, only uranium exceeded their respective cleanup levels.
- For soil concentrations protective of groundwater, cadmium, cyanide, fluoride, manganese, mercury, nitrate, nitrite, silver, tributyl phosphate, and uranium are all above the concentration predicted by the MTCA fixed parameter three-phase model. Cadmium, cyanide, mercury, and silver are listed as dangerous constituents per WAC 173-303-9905.

5.5.2 WAC 173-340 Ecological Risk

WAC 173-340-900, "Tables" includes the following tables:"

- Table 749-2, "Priority Contaminants of Ecological Concern for Sites that Qualify for the Simplified Terrestrial Ecological Evaluation Procedure"
- Table 749-3, "Ecological Indicator Soil Concentrations (mg/kg) for Protection of Terrestrial Plants and Animals."

Table 5-9. Average and 95% Upper Limit Concentrations of Selected Constituents Estimated for Waste Residuals within Tank 241-C-102, Soil Cleanup Levels for Method B and C Direct Contact Exposure, and Soil Concentrations Protective of Groundwater.

Analyte	Average Concentration (mg/kg)[a]	95% Upper Confidence Level Concentration (mg/kg)[b]	Soil Cleanup Level (mg/kg) – Direct Contact Method B	Soil Cleanup Level (mg/kg) – Direct Contact Method C	Soil Concentrations (mg/kg) – Protective of Groundwater	Lognormal 90 Percentile Background Value (mg/kg)[d,e,f]	Above Detection Limits
Acetate	1.15E+02	1.28E+02	--	--	--	--	Yes
Aluminum	2.61E+05	2.72E+05	8.00E+04	3.50E+06	4.80E+05	1.18E+04	Yes
Ammonia	2.50E+00	2.95E+00	--	--	--	9.23E+00	Yes
Barium[g]	6.35E+00	9.16E+00	--	--	--	--	Yes
Beryllium[g]	1.40E+00	1.76E+00	1.60E+02	7.00E+03	6.32E+01	1.51E+00	Yes
Butylbenzylphthalate[g]	1.00E+00	1.29E+00	5.26E+02	6.91E+04	1.29E+01	--	Yes
Cadmium[g]	1.17E+00	1.33E+00	8.00E+01	3.50E+03	6.90E-01	5.63E-01	Yes
Calcium	1.66E+02	2.10E+02	--	--	--	1.72E+04	Yes
Chloride	8.80E+01	1.04E+02	--	--	1.00E+03	1.00E+02	Yes
Chromium, Total[g]	1.17E+02	2.46E+02	1.20E+05	5.25E+06	2.00E+03	1.85E+01	Yes
Copper	8.66E+01	1.26E+02	3.20E+03	1.40E+05	2.84E+02	2.20E+01	Yes
Cyanide[g]	4.39E+01	5.59E+01	4.80E+01	2.10E+03	9.70E-01	--	Yes
Di (2-ethylhexyl) phthalate (DEHP)	3.72E+00	5.97E+00	7.14E+01	9.38E+03	1.34E+01	--	Yes
Di-n-butylphthalate[g]	6.60E-01	8.93E-01	8.00E+03	3.50E+05	5.66E+01	--	Yes
Fluoride	3.02E+03	4.90E+03	4.80E+03	2.10E+05	2.88E+03	2.81E+00	Yes
Formate+A2	1.18E+02	1.58E+02	--	--	--	--	Yes
Hydroxide OH	7.36E+00	1.48E+01	--	--	--	--	Yes
Iron	1.72E+03	2.68E+03	5.60E+04	2.45E+06	5.64E+03	3.26E+04	Yes

Table 5-9. Average and 95% Upper Limit Concentrations of Selected Constituents Estimated for Waste Residuals within Tank 241-C-102, Soil Cleanup Levels for Method B and C Direct Contact Exposure, and Soil Concentrations Protective of Groundwater.

Analyte	Average Concentration (mg/kg)[a]	95% Upper Confidence Level Concentration (mg/kg)[b]	Soil Cleanup Level (mg/kg) – Direct Contact Method B	Soil Cleanup Level (mg/kg) – Direct Contact Method C	Soil Concentrations (mg/kg) – Protective of Groundwater	Lognormal 90 Percentile Background Value (mg/kg)[d,e,f]	Above Detection Limits
Lead[g]	4.46E+01	6.70E+01	--	1.00E+03	3.00E+03	1.02E+01	Yes
Magnesium	6.99E+01	7.65E+01	--	--	--	7.06E+03	Yes
Manganese	5.00E+02	1.26E+03	1.12E+04	4.90E+05	5.01E+02	5.12E+02	Yes
Mercury[g]	4.41E+00	1.13E+01	2.40E+01	1.05E+03	2.09E+00	1.30E-02	Yes
Molybdenum	2.43E+00	2.77E+00	4.00E+02	1.75E+04	3.23E+01	4.70E-01	Yes
Nickel[g]	6.15E+00	9.42E+00	--	--	--	--	Yes
Nitrate[c]	5.79E+03	6.85E+03	5.68E+05	2.49E+07	1.80E+02	5.20E+01	Yes
Nitrite	2.95E+03	3.42E+03	2.40E+04	1.05E+06	1.32E+01	--	Yes
Oxalate	1.58E+02	1.79E+02	--	--	--	--	Yes
Phosphate	7.44E+03	1.42E+04	--	--	--	7.85E-01	Yes
Polychlorinated Biphenyls[g]	2.35E-02	3.97E-02	5.00E-01	6.56E+01	--	--	Yes
Potassium	1.14E+02	1.59E+02	--	--	--	2.15E+03	Yes
Samarium	3.81E+01	6.12E+01	--	--	--	--	Yes
Selenium[g]	2.48E-05	3.13E-05	--	--	--	--	Yes
Silicon	8.97E+02	9.81E+02	--	--	--	--	Yes
Silver[g]	5.90E+01	1.16E+02	4.00E+02	1.75E+04	1.36E+01	1.67E-01	Yes
Sodium	3.29E+04	3.93E+04	--	--	--	6.90E+02	Yes
Strontium	1.11E+01	1.75E+01	4.80E+04	2.10E+06	6.76E+03	--	Yes

Table 5-9. Average and 95% Upper Limit Concentrations of Selected Constituents Estimated for Waste Residuals within Tank 241-C-102, Soil Cleanup Levels for Method B and C Direct Contact Exposure, and Soil Concentrations Protective of Groundwater.

Analyte	Average Concentration (mg/kg)[a]	95% Upper Confidence Level Concentration (mg/kg)[b]	Soil Cleanup Level (mg/kg) – Direct Contact Method B	Soil Cleanup Level (mg/kg) – Direct Contact Method C	Soil Concentrations (mg/kg) – Protective of Groundwater	Lognormal 90 Percentile Background Value (mg/kg)[d,e,f]	Above Detection Limits
Sulfate	5.91E+02	6.17E+02	--	--	1.00E+03	2.37E+02	Yes
Tellurium	9.49E+00	1.02E+01	--	--	--	--	Yes
Thorium	2.60E+02	4.78E+02	--	--	--	--	Yes
Tin	2.09E+01	3.21E+01	4.80E+04	2.10E+06	4.80E+04	--	Yes
Titanium	2.84E+01	4.34E+01	--	--	--	--	Yes
Tributyl phosphate	4.53E+00	7.86E+00	1.11E+02	1.46E+04	4.96E-01	--	Yes
Uranium	6.38E+03	1.20E+04	2.40E+02	1.05E+04	2.70E+02	3.21E+00	Yes
Vanadium	5.85E+00	9.48E+00	4.00E+02	1.75E+04	1.60E+03	8.51E+01	Yes
Zinc	5.67E+01	6.88E+01	2.40E+04	1.05E+06	5.97E+03	6.78E+01	Yes
Zirconium	4.16E+02	8.02E+02	--	--	--	--	Yes

a. Mean Concentrations taken from Table A-1, Appendix A of RPP-RPT-59129, *Tank 241-C-102 Residual Waste Inventory Estimates for Component Closure Risk Assessment.*

b. 95% Upper Confidence Level Concentration = Mean Concentration + (1.96 × Mean Concentration × Relative Standard Deviation). Mean Concentrations and Relative Standard Deviation provided in Table A-1 in Appendix A of RPP-RPT-59129.

c. As nitrate, not nitrogen in nitrate; to convert to nitrogen in nitrate divide this number by 4.43.

d. DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*, Rev. 4, Volume 1.

e. DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides.*

f. ECF-HANFORD-11-0038, *Soil Background for Interim Use at the Hanford Site.*

g. Dangerous waste constituent per Washington Administrative Code 173-303-9905, "Dangerous Waste Constituents List." Total Cr is assumed to be Chromium(III), insoluble salts.

-- = Value is not available

Table 5-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Constituents above Detection in 241-C-102 Tank Residual Wastes.

Analyte	Average Concentration (mg/kg)[a]	Ratio of Average Concentrations in Tank 241-C-102 Residual Wastes to Soil Cleanup Standards				
		Soil Direct Contact (Method B)	Soil Direct Contact (Method C)	Soil Concentrations Protective of Groundwater	Above Detection Limits	Above 90 Percentile Background
Acetate	1.15E+02	--	--	--	Yes	--
Aluminum	2.61E+05	3.26E+00	7.46E-02	5.44E-01	Yes	Yes
Ammonia	2.50E+00	--	--	--	Yes	No
Barium[c]	6.35E+00	--	--	--	Yes	--
Beryllium[c]	1.40E+00	8.75E-03	2.00E-04	2.21E-02	Yes	Yes
Butylbenzylphthalate[c]	1.00E+00	1.90E-03	1.45E-05	7.76E-02	Yes	--
Cadmium[c]	1.17E+00	1.46E-02	3.34E-04	1.70E+00	Yes	Yes
Calcium	1.66E+02	--	--	--	Yes	No
Chloride	8.80E+01	--	--	8.80E-02	Yes	Yes
Chromium, Total[c]	1.17E+02	9.75E-04	2.23E-05	5.85E-02	Yes	Yes
Copper	8.66E+01	2.71E-02	6.19E-04	3.05E-01	Yes	Yes
Cyanide[c]	4.39E+01	9.15E-01	2.09E-02	4.53E+01	Yes	--
Di (2-ethylhexyl) phthalate (DEHP)	3.72E+00	5.21E-02	3.97E-04	2.78E-01	Yes	--
Di-n-butylphthalate[c]	6.60E-01	8.25E-05	1.89E-06	1.17E-02	Yes	--
Fluoride	3.02E+03	6.29E-01	1.44E-02	1.05E+00	Yes	Yes
Formate+A2	1.18E+02	--	--	--	Yes	--
Hydroxide OH	7.36E+00	--	--	--	Yes	--
Iron	1.72E+03	3.07E-02	7.02E-04	3.05E-01	Yes	No
Lead[c]	4.46E+01	--	4.46E-02	1.49E-02	Yes	Yes

Table 5-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Constituents above Detection in 241-C-102 Tank Residual Wastes.

Analyte	Average Concentration (mg/kg)[a]	Ratio of Average Concentrations in Tank 241-C-102 Residual Wastes to Soil Cleanup Standards				
		Soil Direct Contact (Method B)	Soil Direct Contact (Method C)	Soil Concentrations Protective of Groundwater	Above Detection Limits	Above 90 Percentile Background
Magnesium	6.99E+01	--	--	--	Yes	No
Manganese	5.00E+02	4.46E-02	1.02E-03	9.99E-01	Yes	Yes
Mercury[c]	4.41E+00	1.84E-01	4.20E-03	2.11E+00	Yes	Yes
Molybdenum	2.43E+00	6.08E-03	1.39E-04	7.52E-02	Yes	Yes
Nickel[c]	6.15E+00	--	--	--	Yes	--
Nitrate[b]	5.79E+03	1.02E-02	2.33E-04	3.22E+01	Yes	Yes
Nitrite	2.95E+03	1.23E-01	2.81E-03	2.23E+02	Yes	--
Oxalate	1.58E+02	--	--	--	Yes	--
Phosphate	7.44E+03	--	--	--	Yes	Yes
Polychlorinated Biphenyls[c]	2.35E-02	4.70E-02	3.58E-04	--	Yes	--
Potassium	1.14E+02	--	--	--	Yes	No
Samarium	3.81E+01	--	--	--	Yes	--
Selenium[c]	2.48E-05	--	--	--	Yes	--
Silicon	8.97E+02	--	--	--	Yes	--
Silver[c]	5.90E+01	1.48E-01	3.37E-03	4.34E+00	Yes	Yes
Sodium	3.29E+04	--	--	--	Yes	Yes
Strontium	1.11E+01	2.31E-04	5.29E-06	1.64E-03	Yes	--
Sulfate	5.91E+02	--	--	5.91E-01	Yes	Yes
Tellurium	9.49E+00	--	--	--	Yes	--

Table 5-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Constituents above Detection in 241-C-102 Tank Residual Wastes.

Analyte	Average Concentration (mg/kg)[a]	Ratio of Average Concentrations in Tank 241-C-102 Residual Wastes to Soil Cleanup Standards				
		Soil Direct Contact (Method B)	Soil Direct Contact (Method C)	Soil Concentrations Protective of Groundwater	Above Detection Limits	Above 90 Percentile Background
Thorium	2.60E+02	--	--	--	Yes	--
Tin	2.09E+01	4.35E-04	9.95E-06	4.35E-04	Yes	--
Titanium	2.84E+01	--	--	--	Yes	--
Tributyl phosphate	4.53E+00	4.08E-02	3.11E-04	9.14E+00	Yes	--
Uranium	6.38E+03	2.66E+01	6.08E-01	2.36E+01	Yes	Yes
Vanadium	5.85E+00	1.46E-02	3.34E-04	3.66E-03	Yes	No
Zinc	5.67E+01	2.36E-03	5.40E-05	9.50E-03	Yes	Yes
Zirconium	4.16E+02	--	--	--	Yes	--

a. Mean Concentrations taken from Table A-1, Appendix A of RPP-RPT-59129, *Tank 241-C-102 Residual Waste Inventory Estimates for Component Closure Risk Assessment.*

b. As nitrate, not nitrogen in nitrate; to convert to nitrogen in nitrate divide this number by 4.43.

c. Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List." Total Cr is assumed to be Chromium (III), insoluble salts.

-- = Value is not available

Table 5-11. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Constituents above Detection in 241-C-102 Tank Residual Wastes.

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-102 Residual Wastes to Soil Cleanup Standards				
		Soil Direct Contact (Method B)	Soil Direct Contact (Method C)	Soil Concentrations Protective of Groundwater	Above Detection Limits	Above 90 Percentile Background
Acetate	1.28E+02	--	--	--	Yes	--
Aluminum	2.72E+05	3.41E+00	7.78E-02	5.67E-01	Yes	Yes
Ammonia	2.95E+00	--	--	--	Yes	No
Barium[c]	9.16E+00	--	--	--	Yes	--
Beryllium[c]	1.76E+00	1.10E-02	2.51E-04	2.78E-02	Yes	Yes
Butylbenzylphthalate[c]	1.29E+00	2.46E-03	1.87E-05	1.00E-01	Yes	--
Cadmium[c]	1.33E+00	1.66E-02	3.80E-04	1.93E+00	Yes	Yes
Calcium	2.10E+02	--	--	--	Yes	No
Chloride	1.04E+02	--	--	1.04E-01	Yes	Yes
Chromium, Total[c]	2.46E+02	2.05E-03	4.68E-05	1.23E-01	Yes	Yes
Copper	1.26E+02	3.93E-02	8.99E-04	4.43E-01	Yes	Yes
Cyanide[c]	5.59E+01	1.17E+00	2.66E-02	5.77E+01	Yes	--
Di (2-ethylhexyl) phthalate (DEHP)	5.97E+00	8.35E-02	6.36E-04	4.47E-01	Yes	--
Di-n-butylphthalate[c]	8.93E-01	1.12E-04	2.55E-06	1.58E-02	Yes	--
Fluoride	4.90E+03	1.02E+00	2.33E-02	1.70E+00	Yes	Yes
Formate+A2	1.58E+02	--	--	--	Yes	--
Hydroxide OH	1.48E+01	--	--	--	Yes	--
Iron	2.68E+03	4.78E-02	1.09E-03	4.74E-01	Yes	No

Table 5-11. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Constituents above Detection in 241-C-102 Tank Residual Wastes.

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-102 Residual Wastes to Soil Cleanup Standards				
		Soil Direct Contact (Method B)	Soil Direct Contact (Method C)	Soil Concentrations Protective of Groundwater	Above Detection Limits	Above 90 Percentile Background
Lead[c]	6.70E+01	--	6.70E-02	2.23E-02	Yes	Yes
Magnesium	7.65E+01	--	--	--	Yes	No
Manganese	1.26E+03	1.12E-01	2.57E-03	2.51E+00	Yes	Yes
Mercury[c]	1.13E+01	4.71E-01	1.08E-02	5.42E+00	Yes	Yes
Molybdenum	2.77E+00	6.92E-03	1.58E-04	8.56E-02	Yes	Yes
Nickel[c]	9.42E+00	--	--	--	Yes	--
Nitrate[b]	6.85E+03	1.21E-02	2.76E-04	3.80E+01	Yes	Yes
Nitrite	3.42E+03	1.42E-01	3.26E-03	2.59E+02	Yes	--
Oxalate	1.79E+02	--	--	--	Yes	--
Phosphate	1.42E+04	--	--	--	Yes	Yes
Polychlorinated Biphenyls[c]	3.97E-02	7.94E-02	6.05E-04	--	Yes	--
Potassium	1.59E+02	--	--	--	Yes	No
Samarium	6.12E+01	--	--	--	Yes	--
Selenium[c]	3.13E-05	--	--	--	Yes	--
Silicon	9.81E+02	--	--	--	Yes	--
Silver[c]	1.16E+02	2.91E-01	6.65E-03	8.56E+00	Yes	Yes
Sodium	3.93E+04	--	--	--	Yes	Yes
Strontium	1.75E+01	3.64E-04	8.31E-06	2.58E-03	Yes	--

Table 5-11. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Constituents above Detection in 241-C-102 Tank Residual Wastes.

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-102 Residual Wastes to Soil Cleanup Standards				
		Soil Direct Contact (Method B)	Soil Direct Contact (Method C)	Soil Concentrations Protective of Groundwater	Above Detection Limits	Above 90 Percentile Background
Sulfate	6.17E+02	--	--	6.17E-01	Yes	Yes
Tellurium	1.02E+01	--	--	--	Yes	--
Thorium	4.78E+02	--	--	--	Yes	--
Tin	3.21E+01	6.69E-04	1.53E-05	6.69E-04	Yes	--
Titanium	4.34E+01	--	--	--	Yes	--
Tributyl phosphate	7.86E+00	7.07E-02	5.39E-04	1.59E+01	Yes	--
Uranium	1.20E+04	5.02E+01	1.15E+00	4.46E+01	Yes	Yes
Vanadium	9.48E+00	2.37E-02	5.42E-04	5.93E-03	Yes	No
Zinc	6.88E+01	2.87E-03	6.55E-05	1.15E-02	Yes	Yes
Zirconium	8.02E+02	--	--	--	Yes	--

a. 95% Upper Confidence Level Concentration = Mean Concentration + (1.96 × Mean Concentration × Relative Standard Deviation). Mean Concentrations and Relative Standard Deviation provided in Table A-1, Appendix A of RPP-RPT-59129, *Tank 241-C-102 Residual Waste Inventory Estimates for Component Closure Risk Assessment*.

b. As nitrate, not nitrogen in nitrate; to convert to nitrogen in nitrate divide this number by 4.43.

c. Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List." Total Cr is assumed to be Chromium(III), insoluble salts.

-- = Value is not available

Each of these tables contains a footnote stating that it is not intended for the purpose of evaluating sludges or waste, as follows (key statement bolded for this report).

- Table 749-2, footnote a: "Caution on misusing these chemical concentration numbers. These values have been developed for use at sites where a site-specific terrestrial ecological evaluation is not required. They are not intended to be protective of terrestrial ecological receptors at every site. Exceedances of the values in this table do not necessarily trigger requirements for cleanup action under this chapter. **The table is not intended for purposes such as evaluating sludges or wastes.**
  This list does not imply that sampling must be conducted for each of these chemicals at every site. Sampling should be conducted for those chemicals that might be present based on available information, such as current and past uses of chemicals at the site."
- Table 749-3, footnote a: "Caution on misusing ecological indicator concentrations. Exceedances of the values in this table do not necessarily trigger requirements for cleanup action under this chapter. Natural background concentrations may be substituted for ecological indicator concentrations provided in this table. **The table is not intended for purposes such as evaluating sludges or wastes.**
  This list does not imply that sampling must be conducted for each of these chemicals at every site. Sampling should be conducted for those chemicals that might be present based on available information, such as current and past uses of chemicals at the site."

Because of the limitations stated above, comparisons between the concentrations of waste constituents remaining in tank C-102 have not been made against Table 749-2 (under WAC 173-340-7492, "Simplified Terrestrial Ecological Evaluation Procedures," subsection [1] "Purpose") or Table 749-3 (under WAC 173-340-7493, "Site-Specific Terrestrial Ecological Evaluation Procedures," subsection [2] "Problem formulation step," [i] "The chemicals of ecological concern").

5.6 RISK ASSESSMENT SUMMARY

Cumulative analysis results of the risk assessment performed to examine impacts from post-retrieval inventories for tank C-102 are summarized as follows.

- The impacts estimated for residual waste left in tank C-102, using either the average or the 95% UCL inventory, are orders of magnitude below the various performance objectives identified for the groundwater pathway.
- Total ILCRs estimated for all radionuclides range from four orders of magnitude below the performance objective to slightly below the performance objective range of 1.0E-06 to 1.0E-04 ILCR.
- Total ILCRs estimated for all detectable non-radionuclides are one to 11 orders of magnitude below the performance objective of 1.0E-05 ILCR.
- Total hazard indices estimated for all detectable analytes are two to three orders of magnitude below the performance objective of 1.0.
- Estimated doses for all detectable radionuclides are:

- Four orders of magnitude below the performance objective for the all-pathways dose of 25 mrem/yr
- Three orders of magnitude below the performance objective for drinking water dose of 4 mrem/yr.

Following are conclusions about the impacts from key analytes identified in the residual wastes within tank C-102 for each of the performance metrics evaluated.

- **Total ILCR for Radionuclides:** For both the average and 95% UCL inventory, ^{99}Tc and ^{14}C are the primary contributors to the total ILCR for all radionuclides with the industrial land use and residential land use scenarios. The contribution from all other detectable radionuclides, including ^{129}I and the uranium isotopes, was not detectable in residual waste samples, arrived at the WMA C fenceline within the 10,000-year period of interest below concentrations of 1.0E-03 pCi/L, or did not arrive at the WMA C fenceline within the 10,000-year period of interest.
- **Total ILCR for Nonradionuclides:** For both the average and 95% UCL inventory, the contribution from non-radioactive analytes detectable in residual waste samples arrived at the WMA C fenceline within the 10,000-year period of interest below concentrations of 1.0E-03 µg/L, did not arrive at the WMA C fenceline within the 10,000-year period of interest, or did not have available toxicological information.
- **Hazard Indices:** For both the average and 95% UCL inventory, fluoride, nitrate, and nitrite are the primary contributors to the hazard indices. The contribution from other non-radioactive analytes detectable in residual waste samples arrived at the WMA C fenceline within the 10,000-year period of interest below concentrations of 1.0E-03 mg/L, did not arrive at the WMA C fenceline within the 10,000-year period of interest, or did not have available toxicological information.
- **All-Pathways Dose:** For the average and the 95% UCL inventory, ^{99}Tc with a maximum dose rate of 2.98E-03 mrem/yr and 5.09E-03 mrem/yr respectively; and ^{14}C with a maximum dose rate of 6.15E-05 mrem/yr and 7.69E-05 mrem/yr respectively, contributed the majority of the radiological dose for the all-pathways farmer scenario (25 mrem/yr). The contribution from all other radionuclides, including ^{129}I and the uranium isotopes, was not detectable in residual waste samples, arrived at the WMA C fenceline below concentrations of 1.0E-03 pCi/L, or did not arrive at the WMA C fenceline within the 10,000-year period of interest.
- **Drinking Water Dose (Target Organ):** For the average and the 95% UCL inventory, ^{99}Tc with a maximum dose rate of 7.56E-03 mrem/yr and 1.29E-02 mrem/yr respectively; and ^{14}C with a maximum dose rate of 2.54E-05 mrem/yr and 3.17E-05 mrem/yr respectively, contributed the majority of the radiological dose for beta/photon emitters (4 mrem/yr target organ dose). The contribution to dose from all other radionuclides, including ^{129}I and the uranium isotopes, was not detectable in residual waste samples, arrived at the WMA C fenceline below concentrations of 1.0E-03 pCi/L, or did not arrive at the WMA C fenceline within the 10,000-year period of interest.
- **Intruder Dose:** Doses calculated from inadvertent intrusion are primarily attributable to doses from ^{90}Sr, ^{137}Cs, ^{239}Pu, and ^{241}Am. The relative contribution and timing of doses from these radionuclides to the total doses estimated during the 1,000-year period of

analysis depends on the scenario considered. In general, dose contributions from ^{90}Sr and ^{137}Cs typically account for the majority of the dose during the first 100 to 200 years. Doses from ^{239}Pu and ^{241}Am contribute the majority of the dose realized after 100 to 200 years. For both average and 95% UCL inventories estimated for tank C-102, none of the inadvertent intruder evaluations produce results that exceed the performance objectives for either acute exposure or chronic exposure after ~100 years following closure.

As additional risk management information, concentrations of constituents remaining in waste residuals within tank C-102 are compared against the MTCA cleanup standards. For MTCA Method B and Method C soil cleanup levels based on human exposure via direct contact or other exposure pathways where contact with the soil is required to complete the pathway, the point of compliance shall be established in the soils throughout the site from the ground surface to 4.5 m (15 ft) below the ground surface. Under a closure configuration, waste residuals left in tank C-102 and other SSTs in WMA C would be expected to be below 4.5 m (15 ft) below ground surface.

For MTCA soil cleanup levels protective of groundwater, the assumption is that constituents of interest are found in soils and are immediately available to be leached by infiltrating precipitation. Under a closure configuration, constituents associated with waste residuals left in tank C-102 and other SSTs in WMA C would be contained within a grout-filled tank, a steel tank liner, and an underlying concrete pad below the liner and would not be immediately available for leaching by infiltrating water.

Following are conclusions about the comparison of tank C-102 water residual concentrations against MTCA cleanup levels.

- **MTCA Method B Unrestricted Land Use:** For both the average and 95% UCL inventory, aluminum cyanide, and uranium are above the cleanup levels. Cyanide is listed as a dangerous constituent per WAC 173-303-9905.
- **MTCA Method C Industrial Land Use:** For both the average and 95% UCL inventory, only uranium is above the cleanup levels. Lead is listed as a dangerous constituent per WAC 173-303-9905.
- **MTCA Soil Concentrations Protective of Groundwater:** For both the average and 95% UCL inventory, cadmium, cyanide, fluoride, manganese, mercury, nitrate, nitrite, silver, tributyl phosphate, and uranium are greater than the soil cleanup level. Cadmium, cyanide, mercury, and silver are listed as dangerous constituents per WAC 173-303-9905.

Table 5-12 provides a comparison of the inventory used in DOE/ORP-2005-01 against the inventory for detected analytes calculated using post-retrieval samples for the average inventory and the 95% UCL inventories. For the purpose of this comparison, Table 5-12 includes inventories calculated from the laboratory's minimum detection limit for an analyte. Inventories calculated from one half of the laboratory's minimum detection limit are included in the risk assessment analysis. The following observations are made from the comparison of the Hanford Tank Waste Operations Simulator (HTWOS) and post-retrieval inventories.

- Comparison of the HTWOS estimated inventories and post-retrieval inventories for analytes important for assessment of groundwater impacts are as follows:

  - Post-retrieval inventories for ^{14}C are approximately 1.8 to 2.2 times greater than HTWOS estimates for ^{14}C
  - Post-retrieval inventories for ^{99}Tc are approximately 270 to 460 times greater than the HTWOS estimate for ^{99}Tc
  - Post-retrieval inventories for chromium are approximately 1.9 to 4.0 times greater than the HTWOS estimate for chromium
  - Post-retrieval inventories for nitrate are approximately 2.8 to 3.3 times greater than the HTWOS estimates for nitrate
  - Post-retrieval inventories for nitrite are approximately 4.8 to 5.7 times greater than the HTWOS estimates for nitrite
  - Post-retrieval inventories for fluoride are approximately 4.8 to 5.7 times greater than the HTWOS estimate for fluoride.
- Comparison of the HTWOS estimated inventories and post-retrieval inventories for analytes important to assessing inadvertent intruder impacts are as follows:
  - Post-retrieval inventories for ^{90}Sr are approximately 2.2 to 3.7 times greater than HTWOS estimates for ^{90}Sr
  - Post-retrieval inventories for ^{137}Cs are 5.2 to 7.7 times greater than the HTWOS inventory estimates for ^{137}Cs
  - Post-retrieval inventories for ^{232}Th are approximately 0.2 to 0.4 times less than the HTWOS estimates for ^{232}Th
  - Post-retrieval inventories for the plutonium isotopes are 0.5 times less than to 3.9 times greater than those in the HTWOS estimate
  - Post-retrieval inventories for ^{241}Am are approximately 1.8 to 3.5 times greater than those in the HTWOS estimate
  - Post-retrieval inventories for the uranium isotopes range from 0.3 times less than to 15 times greater than estimated in the HTWOS inventory.

Table 5-12. Comparison of Hanford Tank Waste Operations Simulator Predicted Inventory Used in DOE/ORP-2005-01 with the Average and 95% Upper Confidence Level Post-Retrieval Inventories.

Analyte		Units	DOE/ORP-2005-01[a] (HTWOS Predicted)	Average Post-Retrieval Inventory[b]	95% UCL Inventory[b]	Detected in Residual Wastes	Ratio Average/ HTWOS	Ratio Bounding/ HTWOS
Analytes Important for Groundwater Impacts	^{14}C	Ci	4.72E-03	8.24E-03	1.03E-02	Yes	1.75E+00	2.18E+00
	^{99}Tc	Ci	1.58E-03	4.26E-01	7.27E-01	Yes	2.70E+02	4.60E+02
	Chromium, Total	Kg	5.83E+00	1.10E+01	2.34E+01	Yes	1.89E+00	4.01E+00
	Fluoride	Kg	1.26E+01	2.85E+02	4.67E+02	Yes	2.26E+01	3.71E+01
	Nitrate	Kg	1.99E+02	5.47E+02	6.57E+02	Yes	2.75E+00	3.30E+00
	Nitrite	Kg	5.78E+01	2.78E+02	3.28E+02	Yes	4.81E+00	5.67E+00
Analytes Important for Inadvertent Intruder	^{90}Sr	Ci	2.52E+02	5.54E+02	9.43E+02	Yes	2.20E+00	3.74E+00
	^{137}Cs	Ci	1.21E+02	6.35E+02	9.27E+02	Yes	5.24E+00	7.65E+00
	^{232}Th	Ci	1.15E-02	2.70E-03	5.04E-03	Yes	2.35E-01	4.39E-01
	^{233}U	Ci	1.09E+00	3.14E-01	5.58E-01	Yes	2.87E-01	5.10E-01
	^{234}U	Ci	5.72E-02	1.95E-01	3.81E-01	Yes	3.41E+00	6.67E+00
	^{235}U	Ci	2.15E-03	8.40E-03	1.63E-02	Yes	3.90E+00	7.57E+00
	^{236}U	Ci	7.21E-04	5.48E-03	1.05E-02	Yes	7.60E+00	1.46E+01
	^{238}U	Ci	4.93E-02	2.01E-01	3.90E-01	Yes	4.08E+00	7.92E+00
	^{237}Np	Ci	2.61E-05	4.03E-03	6.67E-03	Yes	1.54E+02	2.55E+02
	^{238}Pu	Ci	8.44E-01	5.57E-01	1.03E+00	Yes	6.60E-01	1.22E+00
	^{239}Pu	Ci	3.26E+01	6.23E+01	1.27E+02	Yes	1.91E+00	3.89E+00
	^{240}Pu	Ci	7.81E+00	6.66E+00	1.36E+01	Yes	8.52E-01	1.74E+00

Table 5-12. Comparison of Hanford Tank Waste Operations Simulator Predicted Inventory Used in DOE/ORP-2005-01 with the Average and 95% Upper Confidence Level Post-Retrieval Inventories.

Analyte		Units	DOE/ORP-2005-01[a] (HTWOS Predicted)	Average Post-Retrieval Inventory[b]	95% UCL Inventory[b]	Detected in Residual Wastes	Ratio Average/ HTWOS	Ratio Bounding/ HTWOS
	^{241}Pu	Ci	5.28E+01	2.67E+01	5.32E+01	Yes	5.05E-01	1.01E+00
	^{241}Am	Ci	9.55E+00	1.69E+01	3.35E+01	Yes	1.77E+00	3.51E+00
	^{242}Cm	Ci	6.30E-04	8.72E-03	2.62E-02	No	N/A	N/A
	^{243}Cm	Ci	4.60E-05	2.54E-05	5.03E-05	Yes	5.52E-01	1.09E+00
	^{244}Cm	Ci	1.20E-03	4.84E-04	9.59E-04	Yes	4.04E-01	8.01E-01

[a] Inventories for contaminants having the greatest impact for groundwater or inadvertent intruder pathway.

[b] Includes inventories in sludge calculated from one half of the laboratory's minimum detection limit for an analyte.

Reference: DOE/ORP-2005-01, Initial Single-Shell Tank System Performance Assessment for the Hanford Site.

HTWOS = Hanford Tank Waste Operations Simulator

N/A = Not applicable

UCL = upper confidence level

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6. OPPORTUNITIES AND ACTIONS BEING TAKEN TO REFINE OR DEVELOP TANK WASTE RETRIEVAL TECHNOLOGIES, BASED ON LESSONS LEARNED

This section discusses aspects of the tank C-102 waste retrieval operations, provides recommendations for further actions, and addresses opportunities to refine waste retrieval technologies based on lessons learned from the tank C-102 retrieval operation. The format of this section is to provide brief discussions of the major Lessons-Learned topic areas; some of those areas are taken from other tank waste retrieval activities.

There are opportunities to improve future waste retrieval operations by looking at the ways to modify equipment, make operational changes (e.g., operating sequencing and conditions), plan work, and enhance the design and fabrication of equipment. All RDRs have a Lessons Learned section and it must be recognized that previously identified lessons learned have been incorporated in the formulation and operation of subsequent tank waste retrieval operations, and in the tank C-102 retrieval operation but are not presented here.

6.1 POTENTIAL ENHANCEMENTS

Improvements implemented during the retrieval of tank C-102 are as follows.

- Tank C-102 was the third tank to use the ERSS for retrieving tank waste. The ERSS is different from a standard sluicer in that it has a boom, as well as a mast, which can be used to place the sluicer nozzle closer to the waste and increase the effectiveness in breaking up solid waste in the tank. The ERSSs used in tank C-102 were shorter, boom extension range of 2.4 m to 4.5 m (8 to 15 ft), then prior ERSS used in tanks C-112 and C-101 which had boom extension ranges of 4.5 m to 8.5 m (15 to 28 ft). This was because of higher waste levels at the start of retrieval, the two shorter ERSSs were used until waste levels were amenable to the longer reaching ERSS.
- The longer reaching ERSS deployed in tank C-102 had hydraulic hoses that were made from electrically conductive Teflon[5] instead of non-conductive Teflon. This was done in response to pinhole leaks caused by electrostatic discharges to the non-conductive Teflon hoses.
- A go/no gauge was used prior to loading in sluicing systems to determine if they could be installed without excessive force and/or potential damage and the gauge gave an indication that the riser had a slight bend to it.
- A FARO[6] laser was used to obtain a scan of the riser and determine the angle of riser bend so that installation of the sluicer could be done with minimizing the chance for damage. For C-102 this was implemented with the go/no go gauge to achieve the most accurate dimensions.

These improvements made during the C-102 retrieval will be incorporated as applicable in future tank retrievals.

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[5] Teflon is a trademark of The Chemours Company, Wilmington, Delaware.

[6] FARO is a registered trademark of FARO Global Headquarters, Lake Mary, Florida.

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7. LEAK DETECTION, MONITORING, AND MITIGATION

The Leak Detection, Monitoring and Mitigation (LDMM) program was implemented to protect the workers, public, and environment from leaks of radioactive liquid waste. The LDMM program included technologies and methods used prior to, during, and after waste retrieval to detect leaks, reduce the potential for a leak to occur, or minimize leak volumes.

The operational history and decades of waste and liquid level monitoring indicate that tank C-102 had not leaked and was sound before starting retrieval (HNF-EP-0182, *Waste Tank Summary Report for Month Ending May 31, 2016*, Rev. 341). Additionally, there was no evidence of a leak during retrieval of waste from tank C-102.

The following sections describe the LDMM requirements, leak detection monitoring implementation, mitigative approach, chronology, and results. The major results for the LDMM program during tank C-102 waste retrieval were as follows.

a. Drywell moisture and gamma logging showed no evidence of leaks during the tank C-102 waste retrieval.
b. Modified static level monitoring demonstrated no evidence to support leakage during retrieval.
c. Material balance calculations showed no evidence of leaks during the tank C-102 waste retrieval.
d. A high-resolution resistivity (HRR) system was deployed with drywells and the tank thermocouple as electrodes to detect changes in baseline soil moisture levels.

Retrieval of tank C-102 was begun and the waste in the tank was removed under work plan RPP-22393, Revision 7.

7.1 REQUIREMENTS

Details of the LDMM program are presented in RPP-22393. The leak detection and monitoring (LDM) system requirements are contained in the safety basis controls given in HNF-SD-WM-TSR-006, *Tank Farms Technical Safety Requirements,* specifically Technical Safety Requirement (TSR) Limiting Condition for Operation Section 3.1.1, "Transfer Leak Detection Systems." Material balances during transfers are required by the TSR Administrative Control Section 5.11, "Transfer Control," and RPP-12711, *Temporary Waste Transfer Line Management Program Plan.* The primary procedures governing notification and reporting of leaks are TFC-OPS-OPER-C-24, "Occurrence Reporting and Processing of Operations Information," and TFC-ESHQ-ENV_FS-C-01, "Environmental Notification." Table 7-1 presents the tank C-102 LDM functions and requirements.

7.2 LEAK DETECTION AND TANK MONITORING

During the sluicing retrieval of tank C-102, HRR was used as the primary leak detection method with drywell moisture logging as a backup. Moisture logging is used when the tank is in retrieval status and not in active retrieval and the HRR system is shut-off for greater than 7 calendar days. The frequency of moisture logging depends on whether the tank meets the interim stabilization criteria. If the interim stabilization criteria is exceeded the TWRWP (RPP-22393) requires weekly moisture logging except for tank C-102. In lieu of weekly moisture logging the HRR was used for 30 days each quarter when the tank was not in active retrieval. Figure 7-1 is a timeline of retrieval operations and the leak detection methods used. Leak detection and monitoring was accomplished by the use of HRR, drywell monitoring, visual inspection, leak detectors, Enraf[7] gauges in tank AN-101, radiological monitoring, and material balances as shown in Table 7-2 and discussed in Sections 7.2.1 through 7.2.3.

Table 7-1. Tank 241-C-102 Leak Detection and Monitoring Functions and Requirements.

Function	Requirement	Basis	Key Elements
Detect leaks during waste retrieval from SST	The leak detection and monitoring (LDM) system shall be capable of detecting liquid waste releases during all waste retrieval operations.	Washington Administrative Code (WAC) 173-303	Utilize LDM technologies to detect loss of liquid from a tank; see Section 7.2.
Monitor leaks from SST during waste retrieval	The waste retrieval system (WRS) shall be capable of providing data to support quantifying leak volumes from the tanks in the event a release is detected during waste retrieval operations.	WAC 173-303	Utilize both ex-tank LDM technologies and process data that will allow estimate of leak volume and migration rate to be developed to the extent practical in the event of a leak.
Mitigate leaks during SST waste retrieval	The integrated retrieval and LDM system shall be designed and operated to mitigate leaks as the primary means of minimizing environmental impacts from leaks during waste retrieval if they occur.	WAC 173-303	Leak mitigation strategy described in Section 7.3.
WRS secondary containment and leak detection RP103DT.	For ex-tank equipment and piping, the WRS shall incorporate secondary containment and leak-detection design features in accordance with 40 CFR 265.193 and DOE O 435.1.	40 CFR 265 WAC 173-303 DOE O 435.1 RPP-13033 HNF-SD-WM-TSR-006	Provide for safe and compliant transfer of waste to the receiver double-shell tank.

40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart J—Tank Systems, §265.193 Containment and detection of releases

DOE O 435.1, *Radioactive Waste Management*

HNF-SD-WM-TSR-006, Tank Farms Technical Safety Requirements

RPP-13033, *Tank Farms Documented Safety Analysis*

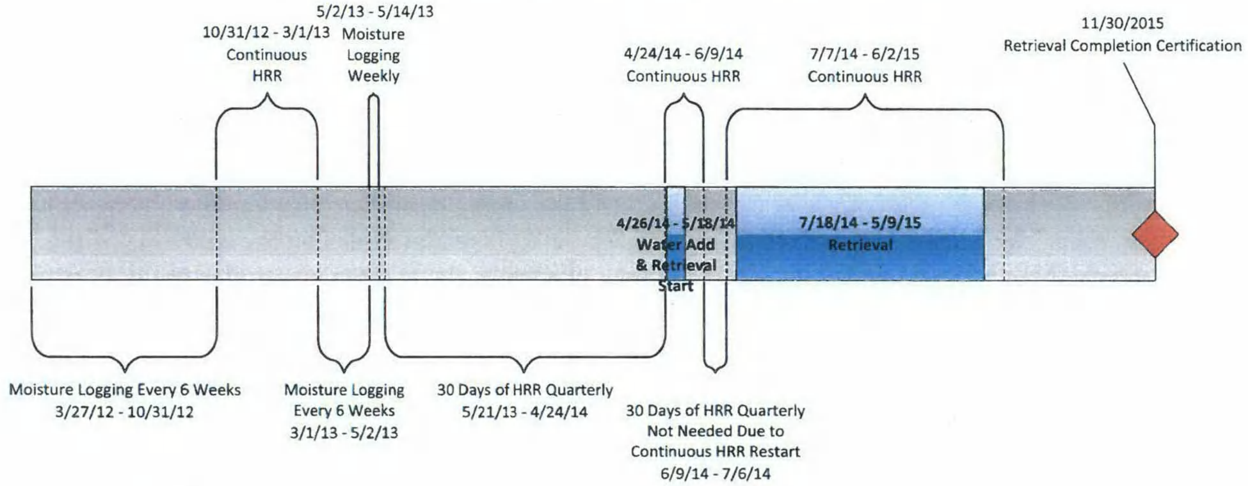
WAC 173-303, "Dangerous Waste Regulations"

DOE = U.S. Department of Energy

SST = single-shell tank

[7] Enraf is a registered trademark of Honeywell International, Inc.

Figure 7-1. Tank 241-C-102 Leak Detection Monitoring Timeline.



HRR = high-resolution resistivity

Table 7-2. Leak Detection and Monitoring Methods for Each Waste Retrieval System Component.

Component	Leak Detection and Monitoring Method
Single-shell tank 241-C-102	Drywells, visual inspection, material balance, and high-resolution resistivity
Double-shell tank 241-AN-101	Liquid level indicators, annulus leak detectors, radiation monitoring for annulus exhaust air
Ancillary equipment (hose-in-hose transfer line)	Secondary containment, leak detectors, radiation monitoring

7.2.1 High-Resolution Resistivity and Drywell Logging

The basic resistivity measurement concept utilizes the existing drywells and a tank electrode (normally the tank thermocouple but in tank C-102 the slurry pump was used as the electrode) as measurement electrodes. Tank C-102 also used three surface electrodes on the east side of the tank where there were no drywells. Like the tank electrode, the surface electrodes are only used as measurement electrodes and not as transmitters. There are reference transmitters and receiver electrodes located a nominal 457 m (1,500 ft) or more from the tank farm. Power is applied to a drywell-reference transmitter electrode pair and an amperage measurement obtained. Concurrently, a voltage measurement is obtained at another electrode-reference receiver electrode pair. Soil resistivity is calculated by dividing the voltage measured across the receiver electrode pair by the current measured across the transmitter pair. These measurements are repeated continuously and the subsequent resistivity data analyzed for changes with time.

Ideally drywell to tank (WTT), drywell to drywell (WTW), and drywell to surface (WTS) resistivity measurements are available to review and are in agreement. During the retrieval the WTW measurements were slightly more variable. Fortunately, the more reliable WTT measurements that are less susceptible to interference, were available most of the time during active retrieval to make a leak determination. When there is no active retrieval, the slurry pump was raised out of the waste to prevent plugging and solids accumulation that might cause difficulty when restarting the pump. It cannot be proven that an electrical pathway exists through the riser on which the slurry pump is mounted but a pathway through structural rebar is suspected to exist.

During retrieval of C-102, three HRR anomalies were evaluated. Table 7-3 identifies the anomalies and provides a description of the anomaly and the resolution. None of the anomalous data indicated a leak of the tank.

Neutron moisture and gamma drywell logging results are reported in 52437-019-SUB-001-003, "241-C-102 Tank Waste Retrieval Project Final Report of Drywell Monitoring Data [HGLP-MBL-018, Rev. 0]". The report concludes that none of the drywells around Tank C 102 show evidence of significant changes in moisture content. Three drywells (30-01-03, 30-01-06 and 30-01-09) indicated increases in moisture content near the tank base before retrieval operations started during April 2013. However, based on a radionuclide assessment system (RAS) measurement in drywell 30-01-01 acquired in this timeframe, no gamma activity was associated with the possible moisture changes. Relatively small moisture increases cannot be readily identified as associated with a tank leak or another moisture event, such as precipitation or an ex-tank water leak. This is why gamma measurements are required to investigate repeatable increases in moisture (RPP-22393). On the basis of moisture and gamma logging measurements, there is no evidence of any leak or contaminant movement associated with tank retrieval operations.

Table 7-3. High-Resolution Resistivity Anomaly Evaluation During and After Sluicing.

Number	Date	Anomaly Description	Resolution/Comments
2012-04	12/17/12	Resistance noise has increased on all tanks being monitored.	Plots were made and trends reviewed. There was no overall change in the trend lines but an obvious increase in the noise that can cause leak potentials to be high.
2014-02	12/4/14	A periodic review of data plots showed short term spikes indicative of electrical discharges and not of a leak. The anomaly evaluation was written for historical purposes.	After several weeks of investigation it was learned that cathodic protections system tests were the source of the electrical spikes in the plots.
2015-02	5/14/15	A large rain event cause leak potential values to increase on all three tanks using HRR.	The HRR system responded as expected to rain but high leak potential values lasted longer than anticipated. A junction box leaked and contained rainwater that resulted in high leak potential values.

HRR = high-resolution resistivity
WTT = drywell-to-tank
WTW = drywell-to-drywell
TS = drywell to surface

7.2.2 Single-Shell Tank 241-C-102

In-tank mitigative actions to minimize the risk of a leak were taken before and during C-102 retrieval. Mitigative actions of in-tank monitoring of tank C-102 were performed by liquid level monitoring, video inspections and material balance calculations.

7.2.2.1 Liquid Level Monitoring. The overall waste retrieval operating strategy for tank C-102 was to reduce the tank liquid inventory and minimize liquid additions during waste retrieval operations. Liquid levels were monitored to evaluate liquid inventories and indicate potential leaks in the system to implement this strategy.

No active retrieval occurred during the stagnant period of January 1, 2013 through April 14, 2013. During these stagnant periods, liquid levels in tanks C-102 and AN-101 did not decrease, indicating that no leaks occurred.

7.2.2.2 Visual Inspection. Before initiating waste retrieval operations, a visual assessment and documentation of in-tank conditions in tank C-102 were performed using an in-tank video camera. Throughout waste retrieval, the closed-circuit television system was used to identify the waste surface condition, qualitatively assess the amount of liquid in the tank, observe any significant changes, and implement the mitigation strategy of minimizing liquid pools.

Observations of the waste surface in tank C-102 indicated that the surface level decrease corresponded with waste retrieval activities.

7.2.2.3 Material Balance. Process control measurements were used periodically to perform a material balance and determine the change in tank C-102 waste inventory. Once determined, the change in waste inventory was compared to the anticipated change (gallons of slurry produced and/or released per gallon of water added, adjusted for changes in the central pool and interstitial liquid volumes).

During retrieval operations, material balances were performed during transfers by Operations for tank leak detection and mitigation for the portion of the system between the portable valve pit and tank AN-101, inclusive. Radiation surveys were required for the portion of the transfer line where volume material balance could not be performed. The frequency of material balance measurements and radiation surveys met the requirements of HNF-IP-1266, *Tank Farms Operations Administrative Controls.*

7.2.3 Double-Shell Tank 241-AN-101

In tank monitoring of tank AN-101 was performed by liquid level monitoring, an annulus leak detection system, radiation monitoring, and leak detectors in ancillary equipment. The following is a summary of leak mitigation actions for 241-AN-101. More detailed information can be found in HNF -3484, *Double-Shell Tank Emergency Pumping Guide* and RPP-5842, *Time Deployment Study for Annulus Pumping.*

7.2.3.1 Liquid Level Monitoring. The waste level in the DST was monitored using an Enraf, and annulus leak detector probes were used to provide indication of leaks, as described in Section 4.0 of OSD-T-151-00031, *Operating Specifications for Tank Farm Leak Detection and Single-Shell Tank Intrusion Detection.*

Daily liquid level measurements were recorded for the receiving DST. The Enraf gauge was capable of measuring liquid level changes to a precision of 0.25 cm (0.1 in.).

During waste retrieval there was no evidence of a release from tank AN-101 based on results of liquid level monitoring. The tank AN-101 liquid level increase corresponded with the material balance results for tank C-102.

7.2.3.2 Leak Detection. Tank AN-101 was monitored for leaks in the inner shell by a conductivity probe leak detection system installed in the tank annulus during tank construction. Slots cut in the concrete that support the tank at the bottom were designed to drain any leakage to the annulus floor. Enraf assemblies in the annulus would have activated an audible alarm and an annunciator panel light in the event of liquid leaking to the annulus so that mitigation could have begun. Throughout the tank C-102 waste retrieval campaign, no leaks were detected by any of the leak detectors in tank AN-101.

7.2.3.3 Radiation Monitoring. A continuous air monitor operated to detect airborne radionuclides entrained in the ventilation exhaust stream of the annulus of tank AN-101. Detection of radiation exceeding a set limit in the annulus of the DST would have activated an audible alarm and an annunciator panel light, initiating mitigative action.

The continuous air monitor for the tank AN-101 annulus detected no radiation levels above background during retrieval that could have been attributed to leak-induced airborne radionuclides.

7.2.4 Ancillary Equipment

Leak detectors were installed in the valve pits to detect the presence of liquid through conductivity, which would have activated alarms and shut down the waste retrieval system.

In accordance with RPP-12711, the hose-in-hose transfer line system underwent radiation monitoring and was equipped with leak detectors as part of the leak detection program.

7.3 MITIGATION

Leak mitigation was accomplished through design features and the operational strategy developed for the retrieval system. Mitigation included actions that reduced the chance of a leak and the environmental impact of a leak should one have occurred. Potential leaks were proactively prevented and minimized throughout the waste retrieval operations.

The leak mitigation strategy (i.e., reduction of leak loss potential) was to minimize the liquid volume within the tank during waste retrieval operations. Conditions to control leak potential involved the following:

a. In-tank liquid levels during retrieval were lower than liquid levels present before interim stabilization
b. Tank C-102 was retrieved from the center out
c. Liquid was removed between waste retrieval operations
d. Leak assessment protocols were in accordance with procedures
e. Drywell surveys were conducted.

Conditions to control leak minimization included the following.

a. Liquid additions were minimized and liquid pools were removed as practical.
b. Tank C-102 was retrieved from the center out.
c. Equipment handling controls were imposed to minimize the potential for dropping equipment that could have penetrated the tank bottom.
d. A benchmark waste level was maintained to ensure a low head of introduced liquid. The waste level did not exceed this benchmark.

7.3.1 Single-Shell Tank 241-C-102

A summary of the tank C-102 mitigation actions to minimize or prevent a leak were as follows.

a. The addition of water to the retrieval tank was minimized to the extent practical.

b. Waste was retrieved to the extent practical by working from the center of the tank outwards. In the center-out waste retrieval strategy, mobilized waste and interstitial liquids drain quickly into a central pool and could have been rapidly pumped from the tank had a leak been detected.

c. Waste sluicing activities were performed only while a video camera was in place to observe the sluicing operation and the waste surface.

d. Equipment handling controls were used to minimize the potential for dropping equipment into the tank, which could have penetrated the tank bottom during installation.

e. A benchmark level was maintained to ensure a low head of introduced liquid. The waste level did not exceed this benchmark.

The mitigative approach was implemented to ensure that potential leakage from tank C-102 was monitored at all times. Key mitigative actions which would have been taken in the event of a leak are described in the Tank Waste Retrieval Work Plan (RPP-22393), Sections 4.6.1 and 4.6.2.

7.3.2 Double-Shell Tank 241-AN-101

Mitigating actions for a leak from AN-101 primary tank piping into the secondary DST containment system during a waste transfer from tank C-102 would have included (1) stopping the flow of waste into the tank system (stopping the transfer), (2) pumping waste in the primary tank to another DST until the liquid level in the secondary containment was no longer increasing, and (3) removing the waste from the secondary containment system as soon as practicable. Leaks at or near the AN-101 tank bottom might have required saltwell jet pumping to remove trapped liquids from between solid layers in the tank. Transfer line leakage would have drained to a common point for collection, detection, and removal.

7.4 CONCLUSION

Based on the available data (presented in Sections 7.2 and 7.3), no evidence of a tank leak occurred during tank C-102 waste retrieval operations. The tank C-102 LDMM program focused on a mitigation strategy to successfully control potential leaks. This strategy included the following.

a. Minimize residual tank waste.

b. Minimize in-tank water use.

c. Minimize standing liquid pools in the tank.

d. Control and monitor additions of water.

e. Visually monitor tank conditions and retrieval operations.

f. Retrieve from the center of the tank out to minimize water accumulation around the tank knuckle.

The goal of the LDMM program for tank C-102 as set forth in RPP-22393 was achieved.

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APPENDIX A

SINGLE-SHELL TANK 241-C-102 INVENTORY PRE- AND POST-SLUICING TECHNOLOGY RETRIEVAL

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Table A-1. Single-Shell Tank 241-C-102 Best-Basis Inventory Pre-Retrieval Inventory and Post-Sluicing Operations.

Constituent Name	BBI February 2005[a]	BBI March 2016[b]		Constituent Name	BBI February 2005[a]	BBI March 2016[b]	
Analyte	**Inventory**	**Inventory**	**Unit**	**Analyte**	**Inventory**	**Inventory**	**Unit**
Al	9.40E+04	2.46E+04	Kg	^{99}Tc	8.87E-01	4.26E-01	Ci
Bi	2.42E+03	1.81E+00	Kg	^{106}Ru	1.76E-07	No Data	Ci
Ca	6.61E+03	1.57E+01	Kg	^{113m}Cd	2.09E+00	No Data	Ci
Cl	1.79E+03	8.31E+00	Kg	^{125}Sb	3.70E-02	1.09E+01	Ci
CN	No Value	4.14E+00	Kg	^{126}Sn	9.58E-03	5.23E-02	Ci
Cr	6.43E+02	1.10E+01	Kg	^{129}I	2.32E-01	1.60E-03	Ci
F	4.14E+03	2.85E+02	Kg	^{134}Cs	6.87E-03	6.35E+02	Ci
Fe	1.76E+04	1.62E+02	Kg	^{137}Cs	2.59E+04	5.99E+02	Ci
Hg	6.05E+00	4.16E-01	Kg	^{137m}Ba	2.45E+04	1.09E+01	Ci
K	1.20E+03	1.07E+01	Kg	^{151}Sm	5.76E+01	No Data	Ci
La	1.18E+02	9.55E-02	Kg	^{152}Eu	1.50E-02	7.96E+00	Ci
Mn	1.50E+03	4.72E+01	Kg	^{154}Eu	2.58E+01	3.41E+00	Ci
Na	1.06E+05	3.10E+03	Kg	^{155}Eu	1.41E+01	7.56E+00	Ci
Ni	6.41E+03	1.17E+02	Kg	^{226}Ra	1.54E-05	No Data	Ci
NO_2	1.90E+04	2.78E+02	Kg	^{227}Ac	1.41E+00	No Data	Ci
NO_3	6.52E+04	5.47E+02	Kg	^{228}Ra	3.92E-01	2.70E-03	Ci
Oxalate	7.31E+02	1.49E+01	Kg	^{229}Th	5.59E-01	No Data	Ci
Pb	1.61E+03	4.21E+00	Kg	^{231}Pa	1.11E-01	No Data	Ci
PO_4	1.64E+04	7.02E+02	Kg	^{232}Th	1.20E+00	2.70E-03	Ci
Si	3.52E+04	8.47E+01	Kg	^{232}U	1.76E+00	2.13E-06	Ci

Table A-1. Single-Shell Tank 241-C-102 Best-Basis Inventory Pre-Retrieval Inventory and Post-Sluicing Operations.

Constituent Name	BBI February 2005[a]	BBI March 2016[b]		Constituent Name	BBI February 2005[a]	BBI March 2016[b]	
Analyte	Inventory	Inventory	Unit	Analyte	Inventory	Inventory	Unit
SO_4	7.20E+03	5.58E+01	Kg	^{233}U	1.15E+02	3.14E-01	Ci
Sr	1.54E+02	1.05E+00	Kg	^{234}U	6.00E+00	1.95E-01	Ci
TIC as CO_3	7.55E+04	No Data	Kg	^{235}U	2.26E-01	8.40E-03	Ci
TOC	1.86E+03	No Data	Kg	^{236}U	7.58E-02	5.48E-03	Ci
U_{TOTAL}	1.55E+04	6.02E+02	Kg	^{237}Np	2.78E-03	4.03E-03	Ci
Zr	5.16E+03	3.92E+01	Kg	^{238}Pu	8.80E+01	5.57E-01	Ci
^{3}H	3.62E+01	1.07E-01	Ci	^{238}U	5.17E+00	2.01E-01	Ci
^{14}C	1.44E+00	8.24E-03	Ci	^{239}Pu	3.40E+03	6.23E+01	Ci
^{59}Ni	8.61E+00	No Data	Ci	^{240}Pu	8.15E+02	6.66E+00	Ci
^{60}Co	9.39E+01	1.53E+00	Ci	^{241}Am	1.02E+03	1.69E+01	Ci
^{63}Ni	8.09E+02	5.81E+02	Ci	^{241}Pu	5.51E+03	2.67E+01	Ci
^{79}Se	2.66E-03	2.34E-03	Ci	^{242}Cm	6.66E-02	8.72E-03	Ci
^{90}Sr	2.80E+04	5.54E+02	Ci	^{242}Pu	4.71E-02	9.18E-05	Ci
^{90}Y	2.80E+04	5.54E+02	Ci	^{243}Am	4.33E-02	1.75E-03	Ci
^{93m}Nb	1.85E-01	No Data	Ci	^{243}Cm	4.86E-03	2.54E-05	Ci
^{93}Zr	2.30E-01	No Data	Ci	^{244}Cm	1.27E-01	4.84E-04	Ci

[a] RPP-22393, 2013, *241-C-102, 241-C-104, 241-C-107, 241-C-108, and 241-C-112 Tanks Waste Retrieval Work Plan*, Rev. 7, Washington River Protection Solutions, LLC, Richland, Washington.

[b] RPP-RPT-57458, 2016, *Derivation of Best-Basis Inventory for Tank 241-C-102 as of March 16, 2016*, Rev. 6, Washington River Protection Solutions, LLC, Richland, Washington.

BBI = Best-Basis Inventory

TIC = total inorganic carbon

TOC = total organic carbon

APPENDIX B

MEAN CONCENTRATIONS AND RELATIVE STANDARD DEVIATIONS FOR TANK 241-C-102 RESIDUAL SOLIDS

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Table B-1. Mean Concentrations and Relative Standard Deviations for Selected Constituents in Tank C-102 Residual Solids.

Constituent Name	CAS Number	< Detection Limit	Mean Concentration*	Units	RSD†
1,4-Dichlorobenzene	106-46-7	<	7.10E-02	ug/g	1.00E+00
125Sb	14234-35-6	<	1.15E-01	uCi/g	1.00E+00
126Sn	15832-50-5	<	5.54E-04	uCi/g	1.00E+00
129I	15046-84-1		1.69E-05	uCi/g	1.93E-01
137Cs	10045-97-3		6.73E+00	uCi/g	2.26E-01
137mBa	N/A		6.35E+00	uCi/g	2.26E-01
14C	14762-75-5		8.72E-05	uCi/g	1.20E-01
152Eu	14683-23-9	<	8.43E-02	uCi/g	1.00E+00
154Eu	15585-10-1	<	3.62E-02	uCi/g	1.00E+00
155Eu	14391-16-3	<	8.01E-02	uCi/g	1.00E+00
228Th	14274-82-9	<	2.51E-04	uCi/g	1.00E+00
230Th	14269-63-7	<	6.41E-03	uCi/g	1.00E+00
232Th	N/A		2.86E-05	uCi/g	4.32E-01
233U	13968-55-3		3.32E-03	uCi/g	3.88E-01
234U	13966-29-5		2.07E-03	uCi/g	4.75E-01
235U	15117-96-1		8.90E-05	uCi/g	4.68E-01
236U	13982-70-2		5.81E-05	uCi/g	4.56E-01
237Np	13994-20-2		4.27E-05	uCi/g	3.26E-01
238Pu	13981-16-3		5.90E-03	uCi/g	4.19E-01
238U	N/A		2.13E-03	uCi/g	4.68E-01
239Pu	15117-48-3		6.60E-01	uCi/g	5.22E-01
240Pu	14119-33-6		7.06E-02	uCi/g	5.22E-01
241Am	14596-10-2		1.79E-01	uCi/g	4.89E-01
241Pu	14119-32-5		2.83E-01	uCi/g	4.95E-01
242Cm	15510-73-3	<	9.24E-05	uCi/g	1.00E+00
242Pu	13982-10-0		9.72E-07	uCi/g	5.22E-01
243Cm	15757-87-6		2.69E-07	uCi/g	4.89E-01
244Cm	13981-15-2		5.13E-06	uCi/g	4.89E-01
2-Butanone	78-93-3	<	1.97E-02	ug/g	1.00E+00
3H	15086-10-9	<	1.13E-03	uCi/g	1.00E+00
4-Methyl-2-Pentanone	108-10-1	<	1.71E-02	ug/g	1.00E+00
60Co	10198-40-0	<	1.62E-02	uCi/g	1.00E+00

Table B-1. Mean Concentrations and Relative Standard Deviations for Selected Constituents in Tank C-102 Residual Solids.

Constituent Name	CAS Number	< Detection Limit	Mean Concentration*	Units	RSD[†]
63Ni	13981-37-8		6.15E+00	uCi/g	2.71E-01
79Se	15758-45-9		2.48E-05	uCi/g	1.34E-01
90Sr	10098-97-2		5.87E+00	uCi/g	3.49E-01
90Y	10098-91-6		5.87E+00	uCi/g	3.49E-01
99Tc	14133-76-7		4.52E-03	uCi/g	3.51E-01
Acetate	71-50-1		1.15E+02	ug/g	5.90E-02
Acetone	67-64-1	<	2.21E-02	ug/g	1.00E+00
Ag	7440-22-4		5.90E+01	ug/g	4.96E-01
Al	7429-90-5		2.61E+05	ug/g	2.23E-02
Aroclors (Total PCB)	1336-36-3		2.35E-02	ug/g	3.52E-01
As	7440-38-2	<	1.52E+01	ug/g	1.00E+00
B	7440-42-8	<	2.02E+00	ug/g	1.00E+00
Ba	7440-39-3		3.76E+00	ug/g	3.00E-01
Be	7440-41-7		1.40E+00	ug/g	1.31E-01
Benzo(a)pyrene	50-32-8	<	1.25E-01	ug/g	1.00E+00
Bi	7440-69-9	<	1.92E+01	ug/g	1.00E+00
Bis(2-ethylhexyl)phthalate	117-81-7		3.72E+00	ug/g	3.08E-01
Br	24959-67-9	<	2.36E+01	ug/g	1.00E+00
Butylbenzylphthalate	85-68-7		1.00E+00	ug/g	1.50E-01
Ca	7440-70-2		1.66E+02	ug/g	1.36E-01
Cd	7440-43-9		1.17E+00	ug/g	6.99E-02
Ce	7440-45-1	<	2.53E+01	ug/g	1.00E+00
Cl	16887-00-6		8.80E+01	ug/g	9.47E-02
CN	57-12-5		4.39E+01	ug/g	1.40E-01
Co	7440-48-4	<	1.05E+00	ug/g	1.00E+00
Cr	7440-47-3		1.17E+02	ug/g	5.61E-01
Cu	7440-50-8		8.66E+01	ug/g	2.31E-01
Dibenz[a,h]anthracene	N/A	<	1.32E-01	ug/g	1.00E+00
Diethylphthalate	84-66-2	<	2.25E-01	ug/g	1.00E+00
Di-n-butylphthalate	84-74-2		6.60E-01	ug/g	1.80E-01
Diphenyl amine	122-39-4	<	1.06E-01	ug/g	1.00E+00
Eu	7440-53-1	<	1.01E+00	ug/g	1.00E+00

Table B-1. Mean Concentrations and Relative Standard Deviations for Selected Constituents in Tank C-102 Residual Solids.

Constituent Name	CAS Number	< Detection Limit	Mean Concentration*	Units	RSD†
F	16984-48-8		3.02E+03	ug/g	3.18E-01
Fe	7439-89-6		1.72E+03	ug/g	2.84E-01
Formate	12311-97-6		1.18E+02	ug/g	1.75E-01
Free OH	N/A		7.36E+00	ug/g	5.19E-01
Glycolate	666-14-8	<	2.52E+01	ug/g	1.00E+00
Hexachlorobenzene	118-74-1	<	9.46E-02	ug/g	1.00E+00
Hg	7439-97-6		4.41E+00	ug/g	7.98E-01
K	7440-09-7		1.14E+02	ug/g	2.02E-01
La	7439-91-0	<	1.01E+00	ug/g	1.00E+00
Li	7439-93-2	<	1.22E+00	ug/g	1.00E+00
Mg	7439-95-4		6.99E+01	ug/g	4.79E-02
Mn	7439-96-5		5.00E+02	ug/g	7.73E-01
Mo	7439-98-7		2.43E+00	ug/g	7.10E-02
Na	7440-23-5		3.29E+04	ug/g	9.90E-02
Nb	7440-03-1	<	6.07E+00	ug/g	1.00E+00
Nd	7440-00-8	<	1.52E+01	ug/g	1.00E+00
NH3	7664-41-7		2.50E+00	ug/g	9.10E-02
Ni	7440-02-0		1.24E+03	ug/g	2.59E-01
N-Nitrosodimethylamine	62-75-9	<	9.78E-02	ug/g	1.00E+00
NO2	14797-65-0		2.95E+03	ug/g	8.10E-02
NO3	14797-55-8		5.79E+03	ug/g	9.32E-02
Oxalate	338-70-5		1.58E+02	ug/g	6.84E-02
Pb	7439-92-1		4.46E+01	ug/g	2.56E-01
Pd	7440-05-3	<	1.21E+01	ug/g	1.00E+00
Pentachlorophenol	87-86-5	<	1.20E-01	ug/g	1.00E+00
Phenol	108-95-2	<	1.13E-01	ug/g	1.00E+00
PO4	14265-44-2		7.44E+03	ug/g	4.67E-01
Pr	7440-10-0	<	2.63E+01	ug/g	1.00E+00
Rb	7440-17-7	<	5.76E+01	ug/g	1.00E+00
Rh	7440-16-6	<	1.21E+01	ug/g	1.00E+00
Ru	7440-18-8	<	5.06E+00	ug/g	1.00E+00
Sb	7440-36-0	<	1.82E+01	ug/g	1.00E+00

Table B-1. Mean Concentrations and Relative Standard Deviations for Selected Constituents in Tank C-102 Residual Solids.

Constituent Name	CAS Number	< Detection Limit	Mean Concentration*	Units	RSD†
Se	7782-49-2	<	3.03E+01	ug/g	1.00E+00
Si	7440-21-3		8.97E+02	ug/g	4.79E-02
Sm	7440-19-9		3.81E+01	ug/g	3.10E-01
Sn	7440-31-5		2.09E+01	ug/g	2.74E-01
SO4	14808-79-8		5.91E+02	ug/g	2.27E-02
Sr	7440-24-6		1.11E+01	ug/g	2.92E-01
Ta	7440-25-7	<	5.06E+00	ug/g	1.00E+00
Te	13494-80-9		9.49E+00	ug/g	3.79E-02
Th	7440-29-1		2.60E+02	ug/g	4.28E-01
Ti	7440-32-6		2.84E+01	ug/g	2.69E-01
Tl	7440-28-0	<	1.52E+01	ug/g	1.00E+00
Toluene	108-88-3	<	8.05E-04	ug/g	1.00E+00
Tributyl phosphate	126-73-8		4.53E+00	ug/g	3.75E-01
Trichloroethene	79-01-6	<	1.21E-03	ug/g	1.00E+00
U	7440-61-1		6.38E+03	ug/g	4.53E-01
V	7440-62-2		5.85E+00	ug/g	3.17E-01
W	7440-33-7	<	1.62E+01	ug/g	1.00E+00
Xylene (m & p)	108-28-3M	<	1.68E-03	ug/g	1.00E+00
Xylene (o)	95-47-6	<	1.02E-03	ug/g	1.00E+00
Xylenes (total)	1330-20-7	<	4.08E-04	ug/g	1.00E+00
Y	7440-65-5	<	2.02E+00	ug/g	1.00E+00
Zn	7440-66-6		5.67E+01	ug/g	1.09E-01
Zr	7440-67-7		4.16E+02	ug/g	4.73E-01

* Radionuclide concentrations are decay corrected to July 1, 2015.

† In accordance with BBI protocol (RPP-7625), the relative standard deviation is assumed to be 1.00 if the constituent was not detected.

CAS = Chemical Abstract Services
NA = not available
RSD = Relative Standard Deviation
uCi/g = microcurie per gram
ug/g = micrograms per gram

APPENDIX C

COMPARISON OF SINGLE-SHELL TANK 241-C-102 FINAL INVENTORY TO SINGLE-SHELL TANK 241-C-102 INVENTORY USED IN DOE/ORP-2005-01, INITIAL SINGLE-SHELL TANK SYSTEM PERFORMANCE ASSESSMENT FOR THE HANFORD SITE

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Table C-1. Comparison of Single-Shell Tank 241-C-102 Final Inventory to Single-Shell Tank 241-C-102 Inventory Used in DOE/ORP-2005-01.

Analyte	Units	DOE/ORP-2005-01, Rev. 0	RPP-RPT-59129, Average Inventory	RPP-RPT-59129, Upper Bounding Inventory
Tritium	Ci	1.10E-01	1.07E-01	3.21E-01
C-14	Ci	4.72E-03	8.24E-03	1.03E-02
I-129	Ci	1.58E-03	1.60E-03	2.23E-03
Tc-99	Ci	3.20E-03	4.26E-01	7.27E-01
Cr	kg	5.83E+00	1.10E+01	2.34E+01
F	kg	1.26E+01	2.85E+02	4.67E+02
NO_2	kg	5.78E+01	2.78E+02	3.28E+02
NO_3	kg	1.99E+02	5.47E+02	6.57E+02
U	kg	1.48E+02	6.02E+02	1.15E+03

DOE/ORP-2005-01, 2006, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site*, Rev. 0, U.S. Department of Energy Office of River Protection, Richland, Washington.

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APPENDIX D

RISK ASSESSMENT INFORMATION FOR RESIDUAL WASTES REMAINING IN SINGLE-SHELL TANK 241-C-102

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This appendix provides risk assessment information related to post-retrieval inventories estimated to remain in single-shell tank (SST) 241-C-102 (tank C-102). The potential risk impacts to human health posed by the residual waste in tank C-102 were evaluated using the methodology documented in DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site*. The process used for the tank C-102 risk assessment, and this methodology, is described in detail in Chapter 3 of DOE/ORP-2005-01. The SST performance assessment methodology represents the current approach being used to support the assessment of long-term impacts to human health from tank residuals left in individual SSTs in retrieval data reports. Decisions on final closure of tank C-102, all other SSTs, and ancillary facilities and equipment within Waste Management Area C will be supported by a site-specific performance assessment as outlined in Appendix I of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989).

The risk assessment-related information for post-retrieval inventories estimated to remain in tank C-102 and contained in this appendix are as follows:

- Summary of incremental lifetime cancer risk, radiological dose, and drinking water dose for radionuclide contaminants of potential concern estimated in the average post-retrieval inventory for tank C-102 (Table D-1)
- Summary of maximum value for incremental lifetime cancer risk and hazard index for non-radionuclide contaminants of potential concern estimated in the average post-retrieval inventory for tank C-102 (Table D-2)
- Summary of incremental lifetime cancer risk, radiological dose, and drinking water dose for radionuclide contaminants of potential concern estimated in the 95% upper confidence level (UCL) post-retrieval inventory for tank C-102 (Table D-3)
- Summary of maximum value for incremental lifetime cancer risk and hazard index for non-radionuclide contaminants of potential concern estimated in the 95% UCL post-retrieval inventory for tank C-102 (Table D-4)
- Tables and plots of doses from a well driller scenario for radioactive contaminants of concern found within the average and 95% UCL inventory estimated for tank C-102 (Table D-5 and Figure D-1)
- Tables and plots of doses from a rural pasture scenario for radioactive contaminants of concern found within the average and 95% UCL inventories estimated for tank C-102 (Table D-6 and Figure D-2)
- Tables and plots of doses from a suburban gardener scenario for radioactive contaminants of concern found within the average and 95% UCL inventories estimated for tank C-102 (Table D-7 and Figure D-3)
- Tables and plots of doses from a commercial farm scenario for radioactive contaminants of concern found within the average and 95% UCL inventories estimated for tank C-102 (Table D-8 and Figure D-4).

Table D-9 provides a comparison of the average and 95% UCL concentrations for waste residuals within tank C-102 against WAC 173-340, "Model Toxics Control Act – Cleanup"

cleanup levels for soil direct contact unrestricted land use (Method B), industrial land use (Method C), and soil concentrations protective of groundwater.

Tables D-10 and D-11 provide additional risk management information related to (average and 95% UCL) concentrations of constituents remaining in waste residuals within tank C-102 compared against the WAC 173-340 cleanup standards. See Section 5.5 for additional discussion.

Table D-12 provides information on background concentration levels at the Hanford Site that have been developed for selected constituents. This is provided to bring additional perspective in the concentration levels of constituents remaining in residual wastes within tank C-102.

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WAC 173-303-9905, "Dangerous Waste Consituents List," *Washington Administrative Code*, as amended.

WAC 173-340, "Model Toxics Control Act – Cleanup," *Washington Administrative Code*, as amended.

Table D-1. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water Dose per Radionuclide Contaminant of Potential Concern for the Average Inventory for Single-Shell Tank 241-C-102.

Analyte Name	Above Detection Limits in Residual Wastes	Inventory (Ci)	Waste Management Area C Fenceline Concentration	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Cancer Risk (Groundwater)[b]		Radiological Dose (mrem/yr) All-Pathway Farmer Scenario[b]	Radiological Dose - Beta/Photon (mrem/yr) Drinking Water Only Scenario[b]
							Industrial	Residential		
Americium-241	Yes	1.69E+01	0.00E+00	DNA	3.00E+00	4.33E+02	NE	NE	NE	NE
Antimony-125	No	5.45E+00	0.00E+00	DNA	1.00E+00	2.73E+00	NE	NE	NE	NE
Barium-137m	Yes	5.99E+02	0.00E+00	DNA	0.00E+00	4.86E-06	NE	NE	NE	NE
Carbon-14	Yes	8.24E-03	1.27E-02	9.78E+03	0.00E+00	5.73E+03	9.86E-11	7.13E-10	6.15E-05	2.54E-05
Cesium-137 + Daughters	Yes	6.35E+02	0.00E+00	DNA	2.50E+01	3.00E+01	NE	NE	NE	NE
Cobalt-60	No	7.65E-01	0.00E+00	DNA	1.00E-01	5.27E+00	NE	NE	NE	NE
Curium-242	No	4.36E-03	0.00E+00	DNA	3.00E+00	4.46E-01	NE	NE	NE	NE
Curium-243	Yes	2.54E-05	0.00E+00	DNA	3.00E+00	2.85E+01	NE	NE	NE	NE
Curium-244	Yes	4.84E-04	0.00E+00	DNA	3.00E+00	1.81E+01	NE	NE	NE	NE
Europium-152	No	3.98E+00	0.00E+00	DNA	1.00E+00	1.33E+01	NE	NE	NE	NE
Europium-154	No	1.71E+00	0.00E+00	DNA	1.00E+00	8.59E+00	NE	NE	NE	NE

Table D-1. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water Dose per Radionuclide Contaminant of Potential Concern for the Average Inventory for Single-Shell Tank 241-C-102.

Analyte Name	Above Detection Limits in Residual Wastes	Inventory (Ci)	Waste Management Area C Fenceline Concentration	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Cancer Risk (Groundwater)[b]		Radiological Dose (mrem/yr) All-Pathway Farmer Scenario[b]	Radiological Dose - Beta/Photon (mrem/yr) Drinking Water Only Scenario[b]
							Industrial	Residential		
Europium-155	No	3.78E+00	0.00E+00	DNA	1.00E+00	4.68E+00	NE	NE	NE	NE
Iodine-129	Yes	1.60E-03	<1.00E-03	1.20E+04	2.00E-01	1.57E+07	NE	NE	NE	NE
Neptunium-237 + D	Yes	4.03E-03	0.00E+00	DNA	2.00E+00	2.14E+06	NE	NE	NE	NE
Nickel-63	Yes	5.81E+02	0.00E+00	DNA	4.80E+01	1.00E+02	NE	NE	NE	NE
Plutonium-238	Yes	5.57E-01	0.00E+00	DNA	3.00E+00	8.77E+01	NE	NE	NE	NE
Plutonium-239	Yes	6.23E+01	0.00E+00	DNA	3.00E+00	2.41E+04	NE	NE	NE	NE
Plutonium-240	Yes	6.66E+00	0.00E+00	DNA	3.00E+00	6.56E+03	NE	NE	NE	NE
Plutonium-241 + D	Yes	2.67E+01	0.00E+00	DNA	3.00E+00	1.44E+01	NE	NE	NE	NE
Plutonium-242	Yes	9.18E-05	0.00E+00	DNA	3.00E+00	3.74E+05	NE	NE	NE	NE
Selenium-79	Yes	2.34E-03	0.00E+00	DNA	3.10E+00	8.05E+05	NE	NE	NE	NE

Table D-1. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water Dose per Radionuclide Contaminant of Potential Concern for the Average Inventory for Single-Shell Tank 241-C-102.

Analyte Name	Above Detection Limits in Residual Wastes	Inventory (Ci)	Waste Management Area C Fenceline Concentration	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Cancer Risk (Groundwater)[b]		Radiological Dose (mrem/yr) All-Pathway Farmer Scenario[b]	Radiological Dose - Beta/Photon (mrem/yr) Drinking Water Only Scenario[b]
							Industrial	Residential		
Strontium-90 + D	Yes	5.54E+02	0.00E+00	DNA	1.61E+01	2.81E+01	NE	NE	NE	NE
Technetium-99	Yes	4.26E-01	1.70E+00	1.05E+04	0.00E+00	2.11E+05	2.34E-08	5.71E-07	2.98E-03	7.56E-03
Thorium-228 + D	No	1.19E-02	0.00E+00	DNA	3.00E+00	1.91E+00	NE	NE	NE	NE
Thorium-230	No	3.03E-01	0.00E+00	DNA	3.00E+00	7.54E+04	NE	NE	NE	NE
Thorium-232	Yes	2.70E-03	0.00E+00	DNA	3.00E+00	1.41E+10	NE	NE	NE	NE
Tin-126	No	2.62E-02	0.00E+00	DNA	1.00E+00	2.46E+05	NE	NE	NE	NE
Tritium	No	5.35E-02	0.00E+00	DNA	0.00E+00	1.23E+01	NE	NE	NE	NE
Uranium-233	Yes	3.14E-01	0.00E+00	DNA	6.00E-01	1.59E+05	NE	NE	NE	NE
Uranium-234	Yes	1.95E-01	0.00E+00	DNA	6.00E-01	2.46E+05	NE	NE	NE	NE
Uranium-235 + D	Yes	8.40E-03	0.00E+00	DNA	6.00E-01	7.04E+08	NE	NE	NE	NE
Uranium-236	Yes	5.48E-03	0.00E+00	DNA	6.00E-01	2.34E+07	NE	NE	NE	NE

Table D-1. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water Dose per Radionuclide Contaminant of Potential Concern for the Average Inventory for Single-Shell Tank 241-C-102.

Analyte Name	Above Detection Limits in Residual Wastes	Inventory (Ci)	Waste Management Area C Fenceline Concentration	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Cancer Risk (Groundwater)[b]		Radiological Dose (mrem/yr) All-Pathway Farmer Scenario[b]	Radiological Dose - Beta/Photon (mrem/yr) Drinking Water Only Scenario[b]
							Industrial	Residential		
Uranium-238 + D	Yes	2.01E-01	0.00E+00	DNA	6.00E-01	4.47E+09	NE	NE	NE	NE
Yttrium-90	Yes	5.54E+02	0.00E+00	DNA	0.00E+00	7.31E-03	NE	NE	NE	NE
Performance Objectives[c]							**1-0E-6 to 1.0E-4**[d]	**1-0E-6 to 1.0E-4**[d]	**25**[e]	**4**[f]

[a] See PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide*, Rev. 1, and Section 4.3 of PNNL-14702, *Vadose Zone Hydrogeology Data Package for Hanford Assessments* for the basis for the K_d values listed for the radionuclides.

[b] All exposure scenarios are described in HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments*.

[c] Performance objectives apply to the cumulative (i.e., all contaminants) for the entire waste management area.

[d] EPA 540/R/99/006, *Radiation Risk Assessment At CERCLA Sites: Q & A*, Directive 9200.4-31P.

[e] DOE O 435.1, *Radioactive Waste Management*.

[f] 65 FR 76708, "National Primary Drinking Water Regulations; Radionuclides; Final Rule."

DNA = Did not arrive at fenceline within the 10,000-year modeling period.

N/A = Radionuclide is not a beta/photon emitter.

NE = Incremental cancer risk for industrial and residential scenarios or radiological dose evaluated for the all-pathways farmer and drinking water only scenarios not evaluated because radiological constituent had no estimated initial inventory or did not arrive in concentrations greater than at the fenceline within the 10,000-year modeling period. In the Decision Management Tool (DMT) that is used to implement the calculational methodology documented in DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site* for this Retrieval Data Report, calculated concentrations less than 1.00E-21 pCi/L are considered to be effectively zero. This risk metric may have also not been calculated because the radioactive analyte was predicted to have a concentration less than 0.001 pCi/L, which is well below the ability of standard laboratory analytical methods to detect it.

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern Using Average Post-Retrieval Inventory for Single-Shell Tank 241-C-102.

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (μg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
1, 1, 2-Trichloroethylene	No	5.75E-05	<1.00E-03	1.20E+04	2.82E-02	NE	NE
1, 4-Dichlorobenzene	No	3.35E-03	<1.00E-03	1.20E+04	1.85E-01	NE	NE
2-Butanone(MEK)	No	9.30E-04	<1.00E-03	1.05E+04	1.35E-03	NE	NE
2-Propanone (Acetone)	No	1.04E-03	<1.00E-03	1.05E+04	1.73E-04	NE	NE
4-Methyl-2-pentanone (MIBK)	No	8.10E-04	<1.00E-03	1.20E+04	4.02E-02	NE	NE
Acetate C2H3O2-	Yes	1.09E+01	4.47E-02	1.05E+04	3.00E-04	No CPF	No Rfd
Aluminum	Yes	2.46E+04	0.00E+00	DNA	1.00E+00	NE	NE
Ammonia	Yes	2.36E-01	<1.00E-03	1.05E+04	9.30E-04	NE	NE
Antimony	No	8.60E-01	0.00E+00	DNA	1.00E+00	NE	NE
Arsenic	No	7.15E-01	0.00E+00	DNA	3.90E+01	NE	NE
Barium	Yes	3.55E-01	0.00E+00	DNA	6.00E+01	NE	NE
Benzo[a]pyrene	No	5.90E-03	0.00E+00	DNA	2.86E+02	NE	NE
Beryllium	Yes	1.32E-01	0.00E+00	DNA	7.00E+01	NE	NE
Bismuth	No	9.05E-01	3.72E-03	1.05E+04	0.00E+00	No CPF	No Rfd

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern Using Average Post-Retrieval Inventory for Single-Shell Tank 241-C-102.

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (μg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Boron	No	9.55E-02	0.00E+00	DNA	3.00E+00	NE	NE
Bromide	No	1.12E+00	4.58E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Butylbenzylphthalate	Yes	9.46E-02	0.00E+00	DNA	4.14E+00	NE	NE
Cadmium	Yes	1.10E-01	0.00E+00	DNA	1.26E+00	NE	NE
Calcium	Yes	1.57E+01	0.00E+00	DNA	4.00E+00	NE	NE
Cerium	No	1.20E+00	4.91E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Chloride	Yes	8.31E+00	3.41E-02	1.05E+04	0.00E+00	No CPF	No Rfd
Chromium, Total	Yes	1.10E+01	4.52E-02	1.05E+04	0.00E+00	No CPF	No Rfd
Cobalt	No	4.95E-02	<1.00E-03	1.20E+04	1.00E-01	NE	NE
Copper	Yes	8.18E+00	0.00E+00	DNA	3.50E+01	NE	NE
Cyanide	Yes	4.14E+00	0.00E+00	DNA	9.90E+00	NE	NE
Di (2-ethylhexyl) phthalate (DEHP)	Yes	3.51E-01	0.00E+00	DNA	2.62E+01	NE	NE
Dibenz[a, h]anthracene	No	6.25E-03	0.00E+00	DNA	5.72E+02	NE	NE
Diethyl phthalate	No	1.06E-02	<1.00E-03	1.20E+04	2.07E-02	NE	NE

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern Using Average Post-Retrieval Inventory for Single-Shell Tank 241-C-102.

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Di-n-butylphthalate	Yes	6.23E-02	0.00E+00	DNA	1.89E+00	NE	NE
Europium	No	4.78E-02	0.00E+00	DNA	5.00E+01	NE	NE
Fluoride	Yes	2.85E+02	1.17E+00	1.05E+04	0.00E+00	No CPF	1.22E-03
Formate+A2	Yes	1.11E+01	4.56E-02	1.05E+04	0.00E+00	No CPF	No Rfd
Glycolate C2H3O3	No	1.19E+00	4.89E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Hexachlorobenzene	No	4.47E-03	0.00E+00	DNA	8.46E+00	NE	NE
Hydroxide OH	Yes	6.95E-01	2.85E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Iron	Yes	1.62E+02	0.00E+00	DNA	2.50E+01	NE	NE
Lanthanum	No	4.78E-02	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Lead	Yes	4.21E+00	0.00E+00	DNA	5.20E+00	NE	NE
Lithium	No	5.75E-02	0.00E+00	DNA	3.00E+02	NE	NE
Magnesium	Yes	6.60E+00	0.00E+00	DNA	4.50E+00	NE	NE
Manganese	Yes	4.72E+01	0.00E+00	DNA	1.00E+00	NE	NE
Mercury	Yes	4.16E-01	0.00E+00	DNA	5.20E+00	NE	NE

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern Using Average Post-Retrieval Inventory for Single-Shell Tank 241-C-102.

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (μg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Molybdenum	Yes	2.29E-01	0.00E+00	DNA	4.00E+00	NE	NE
m-Xylene	No	7.95E-05	<1.00E-03	1.20E+04	5.88E-02	NE	NE
N, N-Diphenylamine	No	5.00E-03	<1.00E-03	1.20E+04	5.73E-01	NE	NE
Neodymium	No	7.15E-01	2.94E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Nickel	Yes	1.17E+02	0.00E+00	DNA	4.80E+01	NE	NE
Niobium	No	2.87E-01	0.00E+00	DNA	1.00E+02	NE	NE
Nitrate	Yes	5.47E+02	2.25E+00	1.05E+04	0.00E+00	No CPF	8.77E-05
Nitrite	Yes	2.78E+02	1.14E+00	1.05E+04	0.00E+00	No CPF	7.13E-04
N-Nitroso-N, N-dimethylamine	No	4.62E-03	<1.00E-03	1.05E+04	3.60E-03	NE	NE
Oxalate	Yes	1.49E+01	6.12E-02	1.05E+04	0.00E+00	No CPF	No Rfd
o-Xylene	No	4.84E-05	<1.00E-03	1.20E+04	7.23E-02	NE	NE
Palladium	No	5.75E-01	0.00E+00	DNA	5.00E+01	NE	NE
Pentachlorophenol	No	5.65E-03	<1.00E-03	1.20E+04	1.77E-01	NE	NE
Phenol	No	5.30E-03	<1.00E-03	1.05E+04	8.64E-03	NE	NE

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern Using Average Post-Retrieval Inventory for Single-Shell Tank 241-C-102.

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (μg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Phosphate	Yes	7.02E+02	2.88E+00	1.05E+04	0.00E+00	No CPF	No Rfd
Polychlorinated Biphenyls (high risk)	Yes	2.22E-03	0.00E+00	DNA	9.27E+01	NE	NE
Potassium	Yes	1.07E+01	4.39E-02	1.05E+04	0.00E+00	No CPF	No Rfd
Praseodymium	No	1.24E+00	5.09E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Rhodium	No	5.75E-01	2.36E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Rubidium	No	2.72E+00	1.12E-02	1.05E+04	0.00E+00	No CPF	No Rfd
Ruthenium	No	2.39E-01	0.00E+00	DNA	1.00E+00	NE	NE
Samarium	Yes	3.60E+00	0.00E+00	DNA	1.00E+00	NE	NE
Selenium	No	1.43E+00	0.00E+00	DNA	5.00E+00	NE	NE
Silicon	Yes	8.47E+01	0.00E+00	DNA	3.00E+01	NE	NE
Silver	Yes	5.57E+00	0.00E+00	DNA	2.70E+00	NE	NE
Sodium	Yes	3.10E+03	1.27E+01	1.05E+04	0.00E+00	No CPF	No Rfd
Strontium	Yes	1.05E+00	0.00E+00	DNA	1.61E+01	NE	NE
Sulfate	Yes	5.58E+01	2.29E-01	1.05E+04	0.00E+00	No CPF	No Rfd

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern Using Average Post-Retrieval Inventory for Single-Shell Tank 241-C-102.

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Tantalum	No	2.39E-01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Tellurium	Yes	8.96E-01	3.68E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Thallium	No	7.15E-01	0.00E+00	DNA	7.10E+01	NE	NE
Thorium	Yes	2.46E+01	0.00E+00	DNA	1.00E+00	NE	NE
Tin	Yes	1.97E+00	0.00E+00	DNA	2.50E+02	NE	NE
Titanium	Yes	2.68E+00	0.00E+00	DNA	1.00E+03	NE	NE
Toluene	No	3.80E-05	<1.00E-03	1.20E+04	4.20E-02	NE	NE
Tributyl phosphate	Yes	4.28E-01	<1.00E-03	1.20E+04	5.67E-01	NE	NE
Tungsten	No	7.65E-01	3.14E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Uranium	Yes	6.02E+02	0.00E+00	DNA	6.00E-01	NE	NE
Vanadium	Yes	5.52E-01	0.00E+00	DNA	5.00E+01	NE	NE
Xylenes	No	1.93E-05	<1.00E-03	1.20E+04	5.88E-02	NE	NE
Yttrium	No	9.55E-02	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Zinc	Yes	5.36E+00	0.00E+00	DNA	6.20E+01	NE	NE

Table D-2. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index per Nonradionuclide Contaminant of Potential Concern Using Average Post-Retrieval Inventory for Single-Shell Tank 241-C-102.

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Zirconium	Yes	3.92E+01	0.00E+00	DNA	5.00E+02	NE	NE
Performance Objective[d]						**1.0E-06[e]**	**1.0[f]**

[a] Dangerous waste constituent per *Washington Administrative Code* (WAC) 173-303-9905, "Dangerous Waste Constituents List."

[b] See PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide*, Rev. 1, for the basis for the K_d values listed for chromium and nitrate. The K_d values listed for the organic chemical compounds are determined from the chemicals' organic carbon/water partitioning coefficient and an estimate of 0.03% for the Hanford Site sediments fraction of organic content (PNNL-13895, Rev. 1, page 11, paragraph 3).

[c] All exposure scenarios are described in HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments*.

[d] Single Analyte Performance objectives apply to entire waste management area, not just a single component of the waste management area.

[e] WAC 173-340-705, "Use of Method B," subpart (2)(c)(ii).

[f] WAC 173-340-705 (2)(c)(i).

DNA = Did not arrive at fenceline within the 10,000-year modeling period.

NE = Incremental cancer risk or hazard quotient calculated under WAC 173-340, "Model Toxics Control Act – Cleanup," Method B not evaluated because hazardous chemical constituent had no estimated initial inventory or did not arrive in concentrations greater than zero at the fenceline within the 10,000-year modeling period. In the Decision Management Tool (DMT) that is used to implement the calculational methodology documented in DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site* for this Retrieval Data Report, calculated concentrations less than 1.00E-21 µg/L are considered to be effectively zero. The risk metric may have also not been calculated because the chemical analyte was predicted to have a concentration less than 0.001 µg/L, which is well below the ability of standard laboratory analytical methods to detect it.

No CPF = No cancer potency factor available.

No Rfd = No reference dose available.

Table D-3. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water Dose for Single-Shell Tank 241-C-102 per Radionuclide Contaminants of Potential Concern Using the 95% Upper Confidence Level Concentration Based Inventory.

Analyte Name	Above Detection Limits in Residual Wastes	Inventory (Ci)	Waste Management Area C Fenceline Concentration	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Cancer Risk (Groundwater)[b]		Radiological Dose (mrem/yr) All-Pathway Farmer Scenario[b]	Radiological Dose - Beta/Photon (mrem/yr) Drinking Water Only Scenario[b]
							Industrial	Residential		
Americium-241	Yes	3.35E+01	0.00E+00	DNA	3.00E+00	4.33E+02	NE	NE	NE	NE
Antimony-125	No	1.64E+01	0.00E+00	DNA	1.00E+00	2.73E+00	NE	NE	NE	NE
Barium-137m	Yes	8.75E+02	0.00E+00	DNA	0.00E+00	4.86E-06	NE	NE	NE	NE
Carbon-14	Yes	1.03E-02	1.59E-02	9.78E+03	0.00E+00	5.73E+03	1.23E-10	8.91E-10	7.69E-05	3.17E-05
Cesium-137 + Daughters	Yes	9.27E+02	0.00E+00	DNA	2.50E+01	3.00E+01	NE	NE	NE	NE
Cobalt-60	No	0.00E+00	0.00E+00	DNA	1.00E-01	5.27E+00	NE	NE	NE	NE
Curium-242	No	1.31E-02	0.00E+00	DNA	3.00E+00	4.46E-01	NE	NE	NE	NE
Curium-243	Yes	5.03E-05	0.00E+00	DNA	3.00E+00	2.85E+01	NE	NE	NE	NE
Curium-244	Yes	9.59E-04	0.00E+00	DNA	3.00E+00	1.81E+01	NE	NE	NE	NE
Europium-152	No	1.20E+01	0.00E+00	DNA	1.00E+00	1.33E+01	NE	NE	NE	NE
Europium-154	No	5.10E+00	0.00E+00	DNA	1.00E+00	8.59E+00	NE	NE	NE	NE
Europium-155	No	1.14E+01	0.00E+00	DNA	1.00E+00	4.68E+00	NE	NE	NE	NE

Table D-3. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water Dose for Single-Shell Tank 241-C-102 per Radionuclide Contaminants of Potential Concern Using the 95% Upper Confidence Level Concentration Based Inventory.

Analyte Name	Above Detection Limits in Residual Wastes	Inventory (Ci)	Waste Management Area C Fenceline Concentration	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Cancer Risk (Groundwater)[b]		Radiological Dose (mrem/yr) All-Pathway Farmer Scenario[b]	Radiological Dose - Beta/Photon (mrem/yr) Drinking Water Only Scenario[b]
							Industrial	Residential		
Iodine-129	Yes	2.23E-03	<1.00E-03	1.20E+04	2.00E-01	1.57E+07	NE	NE	NE	NE
Neptunium-237 + D	Yes	6.67E-03	0.00E+00	DNA	2.00E+00	2.14E+06	NE	NE	NE	NE
Nickel-63	Yes	8.99E+02	0.00E+00	DNA	4.80E+01	1.00E+02	NE	NE	NE	NE
Plutonium-238	Yes	1.03E+00	0.00E+00	DNA	3.00E+00	8.77E+01	NE	NE	NE	NE
Plutonium-239	Yes	1.27E+02	0.00E+00	DNA	3.00E+00	2.41E+04	NE	NE	NE	NE
Plutonium-240	Yes	1.36E+01	0.00E+00	DNA	3.00E+00	6.56E+03	NE	NE	NE	NE
Plutonium-241 + D	Yes	5.32E+01	0.00E+00	DNA	3.00E+00	1.44E+01	NE	NE	NE	NE
Plutonium-242	Yes	1.88E-04	0.00E+00	DNA	3.00E+00	3.74E+05	NE	NE	NE	NE
Selenium-79	Yes	2.99E-03	0.00E+00	DNA	3.10E+00	8.05E+05	NE	NE	NE	NE
Strontium-90 + D	Yes	9.43E+02	0.00E+00	DNA	1.61E+01	2.81E+01	NE	NE	NE	NE
Technetium-99	Yes	7.27E-01	2.90E+00	1.05E+04	0.00E+00	2.11E+05	4.00E-08	9.74E-07	5.09E-03	1.29E-02
Thorium-228 + D	No	3.56E-02	0.00E+00	DNA	3.00E+00	1.91E+00	NE	NE	NE	NE
Thorium-230	No	9.10E-01	0.00E+00	DNA	3.00E+00	7.54E+04	NE	NE	NE	NE

Table D-3. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water Dose for Single-Shell Tank 241-C-102 per Radionuclide Contaminants of Potential Concern Using the 95% Upper Confidence Level Concentration Based Inventory.

Analyte Name	Above Detection Limits in Residual Wastes	Inventory (Ci)	Waste Management Area C Fenceline Concentration	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Cancer Risk (Groundwater)[b]		Radiological Dose (mrem/yr) All-Pathway Farmer Scenario[b]	Radiological Dose - Beta/Photon (mrem/yr) Drinking Water Only Scenario[b]
							Industrial	Residential		
Thorium-232	Yes	5.04E-03	0.00E+00	DNA	3.00E+00	1.41E+10	NE	NE	NE	NE
Tin-126	No	7.85E-02	0.00E+00	DNA	1.00E+00	2.46E+05	NE	NE	NE	NE
Tritium	No	1.61E-01	0.00E+00	DNA	0.00E+00	1.23E+01	NE	NE	NE	NE
Uranium-233	Yes	5.58E-01	0.00E+00	DNA	6.00E-01	1.59E+05	NE	NE	NE	N/A
Uranium-234	Yes	3.81E-01	0.00E+00	DNA	6.00E-01	2.46E+05	NE	NE	NE	N/A
Uranium-235 + D	Yes	1.63E-02	0.00E+00	DNA	6.00E-01	7.04E+08	NE	NE	NE	N/A
Uranium-236	Yes	1.05E-02	0.00E+00	DNA	6.00E-01	2.34E+07	NE	NE	NE	N/A
Uranium-238 + D	Yes	3.90E-01	0.00E+00	DNA	6.00E-01	4.47E+09	NE	NE	NE	N/A
Yttrium-90	Yes	9.43E+02	0.00E+00	DNA	0.00E+00	7.31E-03	NE	NE	NE	NE
Performance Objectives[c]							**1-0E-6 to 1.0E-4**[d]	**1-0E-6 to 1.0E-4**[d]	**25**[e]	**4**[f]

Table D-3. Incremental Lifetime Cancer Risk, Radiological Dose, and Drinking Water Dose for Single-Shell Tank 241-C-102 per Radionuclide Contaminants of Potential Concern Using the 95% Upper Confidence Level Concentration Based Inventory.

Analyte Name	Above Detection Limits in Residual Wastes	Inventory (Ci)	Waste Management Area C Fenceline Concentration	Peak Year	K_d (mL/g)[a]	Half-Life (yr)	Incremental Cancer Risk (Groundwater)[b]		Radiological Dose (mrem/yr) All-Pathway Farmer Scenario[b]	Radiological Dose - Beta/Photon (mrem/yr) Drinking Water Only Scenario[b]
							Industrial	Residential		

[a] See PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide*, Rev. 1, and Section 4.3 of PNNL-14702, *Vadose Zone Hydrogeology Data Package for Hanford Assessments* for the basis for the K_d values listed for the radionuclides.

[b] All exposure scenarios are described in HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments*.

[c] Performance objectives apply to the cumulative (i.e., all contaminants) for the entire waste management area.

[d] EPA 540/R/99/006, *Radiation Risk Assessment At CERCLA Sites: Q & A*, Directive 9200.4-31P.

[e] DOE O 435.1, *Radioactive Waste Management*.

[f] 65 FR 76708, "National Primary Drinking Water Regulations; Radionuclides; Final Rule."

DNA = Did not arrive at fenceline within the 10,000-year modeling period.

N/A = Radionuclide is not a beta/photon emitter.

NE = Incremental cancer risk for industrial and residential scenarios or radiological dose evaluated for the all-pathways farmer and drinking water only scenarios not evaluated because radiological constituent had no estimated initial inventory or did not arrive in concentrations greater than at the fenceline within the 10,000-year modeling period. In the Decision Management Tool (DMT) that is used to implement the calculational methodology documented in DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site* for this Retrieval Data Report, calculated concentrations less than 1.00E-21 pCi/L are considered to be effectively zero. This risk metric may have also not been calculated because the radioactive analyte was predicted to have a concentration less than 0.001 pCi/L, which is well below the ability of standard laboratory analytical methods to detect it.

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index for Single-Shell Tank 241-C-102 per Nonradionuclide Contaminants of Potential Concern Using the 95% Upper Confidence Level Concentration Based Inventory.

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
1, 1, 2-Trichloroethylene	No	1.73E-04	<1.00E-03	1.20E+04	2.82E-02	NE	NE
1, 4-Dichlorobenzene	No	1.01E-02	<1.00E-03	1.20E+04	1.85E-01	NE	NE
2-Butanone(MEK)	No	2.79E-03	<1.00E-03	1.05E+04	1.35E-03	NE	NE
2-Propanone (Acetone)	No	3.12E-03	<1.00E-03	1.05E+04	1.73E-04	NE	NE
4-Methyl-2-pentanone (MIBK)	No	2.43E-03	<1.00E-03	1.20E+04	4.02E-02	NE	NE
Acetate C2H3O2-	Yes	1.24E+01	5.09E-02	1.05E+04	3.00E-04	No CPF	No Rfd
Aluminum	Yes	2.68E+04	0.00E+00	DNA	1.00E+00	NE	NE
Ammonia	Yes	2.83E-01	1.16E-03	1.05E+04	9.30E-04	No CPF	No Rfd
Antimony	No	2.58E+00	0.00E+00	DNA	1.00E+00	NE	NE
Arsenic	No	2.15E+00	0.00E+00	DNA	3.90E+01	NE	NE
Barium	Yes	5.69E-01	0.00E+00	DNA	6.00E+01	NE	NE
Benzo[a]pyrene	No	1.77E-02	0.00E+00	DNA	2.86E+02	NE	NE
Beryllium	Yes	1.68E-01	0.00E+00	DNA	7.00E+01	NE	NE
Bismuth	No	0.00E+00	<1.00E-03	DNA	0.00E+00	NE	NE

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index for Single-Shell Tank 241-C-102 per Nonradionuclide Contaminants of Potential Concern Using the 95% Upper Confidence Level Concentration Based Inventory.

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (μg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Boron	No	2.87E-01	0.00E+00	DNA	3.00E+00	NE	NE
Bromide	No	0.00E+00	<1.00E-03	DNA	0.00E+00	NE	NE
Butylbenzylphthalate	Yes	1.24E-01	0.00E+00	DNA	4.14E+00	NE	NE
Cadmium	Yes	1.28E-01	0.00E+00	DNA	1.26E+00	NE	NE
Calcium	Yes	2.01E+01	0.00E+00	DNA	4.00E+00	NE	NE
Cerium	No	3.59E+00	1.47E-02	1.05E+04	0.00E+00	No CPF	No Rfd
Chloride	Yes	1.00E+01	4.11E-02	1.05E+04	0.00E+00	No CPF	No Rfd
Chromium, Total	Yes	2.34E+01	9.61E-02	1.05E+04	0.00E+00	No CPF	No Rfd
Cobalt	No	1.49E-01	<1.00E-03	1.20E+04	1.00E-01	NE	NE
Copper	Yes	1.20E+01	0.00E+00	DNA	3.50E+01	NE	NE
Cyanide	Yes	5.34E+00	0.00E+00	DNA	9.90E+00	NE	NE
Di (2-ethylhexyl) phthalate (DEHP)	Yes	5.69E-01	0.00E+00	DNA	2.62E+01	NE	NE
Dibenz[a, h]anthracene	No	1.88E-02	0.00E+00	DNA	5.72E+02	NE	NE
Diethyl phthalate	No	0.00E+00	<1.00E-03	DNA	2.07E-02	NE	NE

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index for Single-Shell Tank 241-C-102 per Nonradionuclide Contaminants of Potential Concern Using the 95% Upper Confidence Level Concentration Based Inventory.

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (μg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Di-n-butylphthalate	Yes	0.00E+00	<1.00E-03	DNA	1.89E+00	NE	NE
Europium	No	1.44E-01	0.00E+00	DNA	5.00E+01	NE	NE
Fluoride	Yes	4.67E+02	1.92E+00	1.05E+04	0.00E+00	No CPF	2.00E-03
Formate+A2	Yes	1.51E+01	6.20E-02	1.05E+04	0.00E+00	No CPF	No Rfd
Glycolate C2H3O3	No	3.57E+00	1.47E-02	1.05E+04	0.00E+00	No CPF	No Rfd
Hexachlorobenzene	No	0.00E+00	<1.00E-03	DNA	8.46E+00	NE	NE
Hydroxide OH	Yes	1.42E+00	5.83E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Iron	Yes	2.55E+02	0.00E+00	DNA	2.50E+01	NE	NE
Lanthanum	No	1.44E-01	<1.00E-03	1.05E+04	0.00E+00	NE	NE
Lead	Yes	6.39E+00	0.00E+00	DNA	5.20E+00	NE	NE
Lithium	No	1.73E-01	0.00E+00	DNA	3.00E+02	NE	NE
Magnesium	Yes	7.41E+00	0.00E+00	DNA	4.50E+00	NE	NE
Manganese	Yes	1.20E+02	0.00E+00	DNA	1.00E+00	NE	NE
Mercury	Yes	1.08E+00	0.00E+00	DNA	5.20E+00	NE	NE

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index for Single-Shell Tank 241-C-102 per Nonradionuclide Contaminants of Potential Concern Using the 95% Upper Confidence Level Concentration Based Inventory.

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Molybdenum	Yes	2.66E-01	0.00E+00	DNA	4.00E+00	NE	NE
m-Xylene	No	2.39E-04	<1.00E-03	1.20E+04	5.88E-02	NE	NE
N, N-Diphenylamine	No	0.00E+00	<1.00E-03	DNA	5.73E-01	NE	NE
Neodymium	No	2.15E+00	8.81E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Nickel	Yes	1.78E+02	0.00E+00	DNA	4.80E+01	NE	NE
Niobium	No	8.60E-01	0.00E+00	DNA	1.00E+02	NE	NE
Nitrate	Yes	6.57E+02	2.70E+00	1.05E+04	0.00E+00	No CPF	1.05E-04
Nitrite	Yes	3.28E+02	1.35E+00	1.05E+04	0.00E+00	No CPF	8.42E-04
N-Nitroso-N, N-dimethylamine	No	0.00E+00	<1.00E-03	DNA	3.60E-03	NE	NE
Oxalate	Yes	1.72E+01	7.06E-02	1.05E+04	0.00E+00	No CPF	No Rfd
o-Xylene	No	1.45E-04	<1.00E-03	1.20E+04	7.23E-02	NE	NE
Palladium	No	1.73E+00	0.00E+00	DNA	5.00E+01	NE	NE
Pentachlorophenol	No	1.70E-02	<1.00E-03	1.20E+04	1.77E-01	NE	NE
Phenol	No	1.59E-02	<1.00E-03	1.05E+04	8.64E-03	NE	NE

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index for Single-Shell Tank 241-C-102 per Nonradionuclide Contaminants of Potential Concern Using the 95% Upper Confidence Level Concentration Based Inventory.

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (μg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Phosphate	Yes	1.36E+03	5.58E+00	1.05E+04	0.00E+00	No CPF	No Rfd
Polychlorinated Biphenyls (high risk)	Yes	3.79E-03	0.00E+00	DNA	9.27E+01	NE	NE
Potassium	Yes	1.51E+01	6.20E-02	1.05E+04	0.00E+00	No CPF	No Rfd
Praseodymium	No	3.72E+00	1.53E-02	1.05E+04	0.00E+00	No CPF	No Rfd
Rhodium	No	1.73E+00	7.08E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Rubidium	No	8.15E+00	3.35E-02	1.05E+04	0.00E+00	No CPF	No Rfd
Ruthenium	No	7.15E-01	0.00E+00	DNA	1.00E+00	NE	NE
Samarium	Yes	5.85E+00	0.00E+00	DNA	1.00E+00	NE	NE
Selenium	No	4.29E+00	0.00E+00	DNA	5.00E+00	NE	NE
Silicon	Yes	9.51E+01	0.00E+00	DNA	3.00E+01	NE	NE
Silver	Yes	1.11E+01	0.00E+00	DNA	2.70E+00	NE	NE
Sodium	Yes	3.76E+03	1.54E+01	1.05E+04	0.00E+00	No CPF	No Rfd
Strontium	Yes	1.67E+00	0.00E+00	DNA	1.61E+01	NE	NE
Sulfate	Yes	6.08E+01	2.50E-01	1.05E+04	0.00E+00	No CPF	No Rfd

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index for Single-Shell Tank 241-C-102 per Nonradionuclide Contaminants of Potential Concern Using the 95% Upper Confidence Level Concentration Based Inventory.

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (μg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Tantalum	No	7.15E-01	2.94E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Tellurium	Yes	9.93E-01	4.08E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Thallium	No	2.15E+00	0.00E+00	DNA	7.10E+01	NE	NE
Thorium	Yes	4.58E+01	0.00E+00	DNA	1.00E+00	NE	NE
Tin	Yes	3.06E+00	0.00E+00	DNA	2.50E+02	NE	NE
Titanium	Yes	4.14E+00	0.00E+00	DNA	1.00E+03	NE	NE
Toluene	No	1.14E-04	<1.00E-03	1.20E+04	4.20E-02	NE	NE
Tributyl phosphate	Yes	7.51E-01	<1.00E-03	1.20E+04	5.67E-01	NE	NE
Tungsten	No	2.30E+00	9.42E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Uranium	Yes	1.15E+03	0.00E+00	DNA	6.00E-01	NE	NE
Vanadium	Yes	9.05E-01	0.00E+00	DNA	5.00E+01	NE	NE
Xylenes	No	5.80E-05	<1.00E-03	1.20E+04	5.88E-02	NE	NE
Yttrium	No	2.87E-01	1.18E-03	1.05E+04	0.00E+00	No CPF	No Rfd
Zinc	Yes	6.59E+00	0.00E+00	DNA	6.20E+01	NE	NE

Table D-4. Maximum Value for Incremental Lifetime Cancer Risk and Hazard Index for Single-Shell Tank 241-C-102 per Nonradionuclide Contaminants of Potential Concern Using the 95% Upper Confidence Level Concentration Based Inventory.

Analyte	Above Detection Limits in Residual Waste	Inventory (kg)	Waste Management Area C Fenceline Concentration (µg/L)	Peak Year	K_d (mL/g)[b]	Incremental Lifetime Cancer Risk (Groundwater)[c]	Hazard Quotient (Groundwater)[c]
						WAC 173-340 Method B	
Zirconium	Yes	7.64E+01	0.00E+00	DNA	5.00E+02	NE	NE
Performance Objective[d]						**1.0E-06[e]**	**1.0[f]**

[a] Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List."

[b] See PNNL-13895, *Hanford Contaminant Distribution Coefficient Database and Users Guide*, Rev. 1, for the basis for the K_d values listed for chromium and nitrate. The K_d values listed for the organic chemical compounds are determined from the chemicals' organic carbon/water partitioning coefficient and an estimate of 0.03% for the Hanford Site sediments fraction of organic content (PNNL-13895, Rev. 1, page 11, paragraph 3).

[c] All exposure scenarios are described in HNF-SD-WM-TI-707, *Exposure Scenarios and Unit Factors for Hanford Tank Waste Performance Assessments*.

[d] Single Analyte Performance objectives apply to entire waste management area, not just a single component of the waste management area.

[e] WAC 173-340-705, "Use of Method B," subpart (2)(c)(ii).

[f] WAC 173-340-705 (2)(c)(i).

DNA = Did not arrive at fenceline within the 10,000-year modeling period.

NE = Incremental cancer risk or hazard quotient calculated under WAC 173-340, "Model Toxics Control Act – Cleanup," Method B not evaluated because hazardous chemical constituent had no estimated initial inventory or did not arrive in concentrations greater than zero at the fenceline within the 10,000-year modeling period. In the Decision Management Tool (DMT) that is used to implement the calculational methodology documented in DOE/ORP-2005-01, *Initial Single-Shell Tank System Performance Assessment for the Hanford Site* for this Retrieval Data Report, calculated concentrations less than 1.00E-21 µg/L are considered to be effectively zero. The risk metric may have also not been calculated because the chemical analyte was predicted to have a concentration less than 0.001 µg/L, which is well below the ability of standard laboratory analytical methods to detect it.

No CPF = No cancer potency factor available.

No Rfd = No reference dose available.

Table D-5. Well Driller Scenario Doses (mrem) for Single-Shell Tank 241-C-102 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways.

Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
A – Average Inventory										
Antimony-125	8.85E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tin-126	1.22E-02	1.22E-02	1.22E-02	1.22E-02	1.22E-02	1.21E-02	1.21E-02	1.21E-02	1.21E-02	1.21E-02
Iodine-129	4.77E-06	4.77E-06	4.77E-06	4.77E-06	4.77E-06	4.77E-06	4.77E-06	4.77E-06	4.77E-06	4.77E-06
Cesium-137 + Daughters	4.69E+00	4.65E-01	4.62E-02	4.58E-03	4.54E-04	4.51E-05	4.47E-06	4.44E-07	4.40E-08	4.37E-09
Barium-137m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	1.36E-07	1.34E-07	1.33E-07	1.31E-07	1.30E-07	1.28E-07	1.27E-07	1.25E-07	1.24E-07	1.22E-07
Europium-152	1.56E-03	8.62E-06	4.75E-08	2.62E-10	1.45E-12	1.06E-14	2.64E-15	2.60E-15	2.60E-15	2.60E-15
Europium-154	2.02E-05	6.34E-09	1.99E-12	6.23E-16	1.95E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	3.52E-10	1.30E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-228 + D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	1.43E-02	2.00E-02	2.55E-02	3.07E-02	3.57E-02	4.05E-02	4.51E-02	4.95E-02	5.37E-02	5.77E-02
Thorium-232	1.94E-03	1.94E-03	1.94E-03	1.94E-03	1.94E-03	1.94E-03	1.94E-03	1.94E-03	1.94E-03	1.94E-03
Uranium-233	1.72E-03	2.38E-03	3.03E-03	3.68E-03	4.32E-03	4.95E-03	5.58E-03	6.20E-03	6.81E-03	7.42E-03
Uranium-234	5.40E-04	5.50E-04	5.64E-04	5.80E-04	6.00E-04	6.22E-04	6.47E-04	6.75E-04	7.06E-04	7.38E-04

Table D-5. Well Driller Scenario Doses (mrem) for Single-Shell Tank 241-C-102 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways.

Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
Uranium-235 + D	3.34E-04	3.43E-04	3.52E-04	3.61E-04	3.70E-04	3.79E-04	3.88E-04	3.97E-04	4.06E-04	4.14E-04
Uranium-236	1.42E-05	1.42E-05	1.42E-05	1.42E-05	1.42E-05	1.42E-05	1.42E-05	1.42E-05	1.42E-05	1.42E-05
Neptunium-237 + D	4.92E-04	4.92E-04	4.92E-04	4.92E-04	4.92E-04	4.92E-04	4.93E-04	4.93E-04	4.93E-04	4.93E-04
Plutonium-238	1.09E-02	4.96E-03	2.25E-03	1.02E-03	4.64E-04	2.11E-04	9.59E-05	4.39E-05	2.03E-05	9.61E-06
Uranium-238 + D	1.60E-03	1.60E-03	1.60E-03	1.60E-03	1.60E-03	1.60E-03	1.60E-03	1.60E-03	1.60E-03	1.60E-03
Plutonium-239	3.60E+00	3.59E+00	3.58E+00	3.57E+00	3.56E+00	3.55E+00	3.54E+00	3.53E+00	3.52E+00	3.51E+00
Plutonium-240	3.81E-01	3.77E-01	3.73E-01	3.69E-01	3.65E-01	3.61E-01	3.58E-01	3.54E-01	3.50E-01	3.47E-01
Americium-241	8.66E-01	7.38E-01	6.29E-01	5.36E-01	4.57E-01	3.89E-01	3.32E-01	2.83E-01	2.41E-01	2.05E-01
Plutonium-241 + D	4.69E-02	4.00E-02	3.41E-02	2.90E-02	2.47E-02	2.11E-02	1.80E-02	1.53E-02	1.30E-02	1.11E-02
Curium-242	4.38E-07	1.99E-07	9.01E-08	4.09E-08	1.86E-08	8.43E-09	3.84E-09	1.75E-09	8.07E-10	3.78E-10
Plutonium-242	5.08E-06	5.07E-06	5.07E-06	5.07E-06	5.07E-06	5.07E-06	5.07E-06	5.07E-06	5.07E-06	5.07E-06
Curium-243	8.53E-08	9.09E-09	2.39E-09	1.80E-09	1.74E-09	1.73E-09	1.73E-09	1.72E-09	1.72E-09	1.71E-09
Curium-244	2.10E-07	7.87E-08	7.50E-08	7.42E-08	7.34E-08	7.26E-08	7.19E-08	7.11E-08	7.04E-08	6.96E-08
Tritium	2.32E-11	8.41E-14	3.04E-16	1.10E-18	3.98E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cobalt-60	3.18E-08	6.19E-14	1.21E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table D-5. Well Driller Scenario Doses (mrem) for Single-Shell Tank 241-C-102 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways.

Nuclide	**Years After Site Closure (January 1, 2032)**									
	100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
Nickel-63	1.10E-03	5.52E-04	2.76E-04	1.38E-04	6.92E-05	3.46E-05	1.73E-05	8.67E-06	4.34E-06	2.17E-06
Selenium-79	1.57E-07	1.57E-07	1.57E-07	1.57E-07	1.57E-07	1.57E-07	1.57E-07	1.57E-07	1.57E-07	1.57E-07
Strontium-90 + D	5.81E-02	4.95E-03	4.22E-04	3.60E-05	3.06E-06	2.61E-07	2.23E-08	1.90E-09	1.62E-10	1.38E-11
Yttrium-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	8.08E-06	8.08E-06	8.08E-06	8.08E-06	8.07E-06	8.07E-06	8.07E-06	8.07E-06	8.06E-06	8.06E-06
Total Dose	**9.69E+00**	**5.26E+00**	**4.71E+00**	**4.56E+00**	**4.46E+00**	**4.38E+00**	**4.31E+00**	**4.25E+00**	**4.20E+00**	**4.15E+00**
B – 95% Upper Confidence Level Inventory										
Antimony-125	2.65E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tin-126	3.65E-02	3.65E-02	3.65E-02	3.65E-02	3.65E-02	3.65E-02	3.65E-02	3.64E-02	3.64E-02	3.64E-02
Iodine-129	6.65E-06	6.65E-06	6.65E-06	6.65E-06	6.65E-06	6.65E-06	6.65E-06	6.65E-06	6.65E-06	6.65E-06
Cesium-137 + Daughters	6.85E+00	6.79E-01	6.74E-02	6.69E-03	6.63E-04	6.58E-05	6.53E-06	6.48E-07	6.42E-08	6.37E-09
Barium-137m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	1.70E-07	1.68E-07	1.66E-07	1.64E-07	1.62E-07	1.60E-07	1.58E-07	1.56E-07	1.54E-07	1.53E-07
Europium-152	4.69E-03	2.59E-05	1.43E-07	7.87E-10	4.35E-12	3.18E-14	7.93E-15	7.80E-15	7.80E-15	7.80E-15
Europium-154	6.05E-05	1.90E-08	5.95E-12	1.86E-15	5.85E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

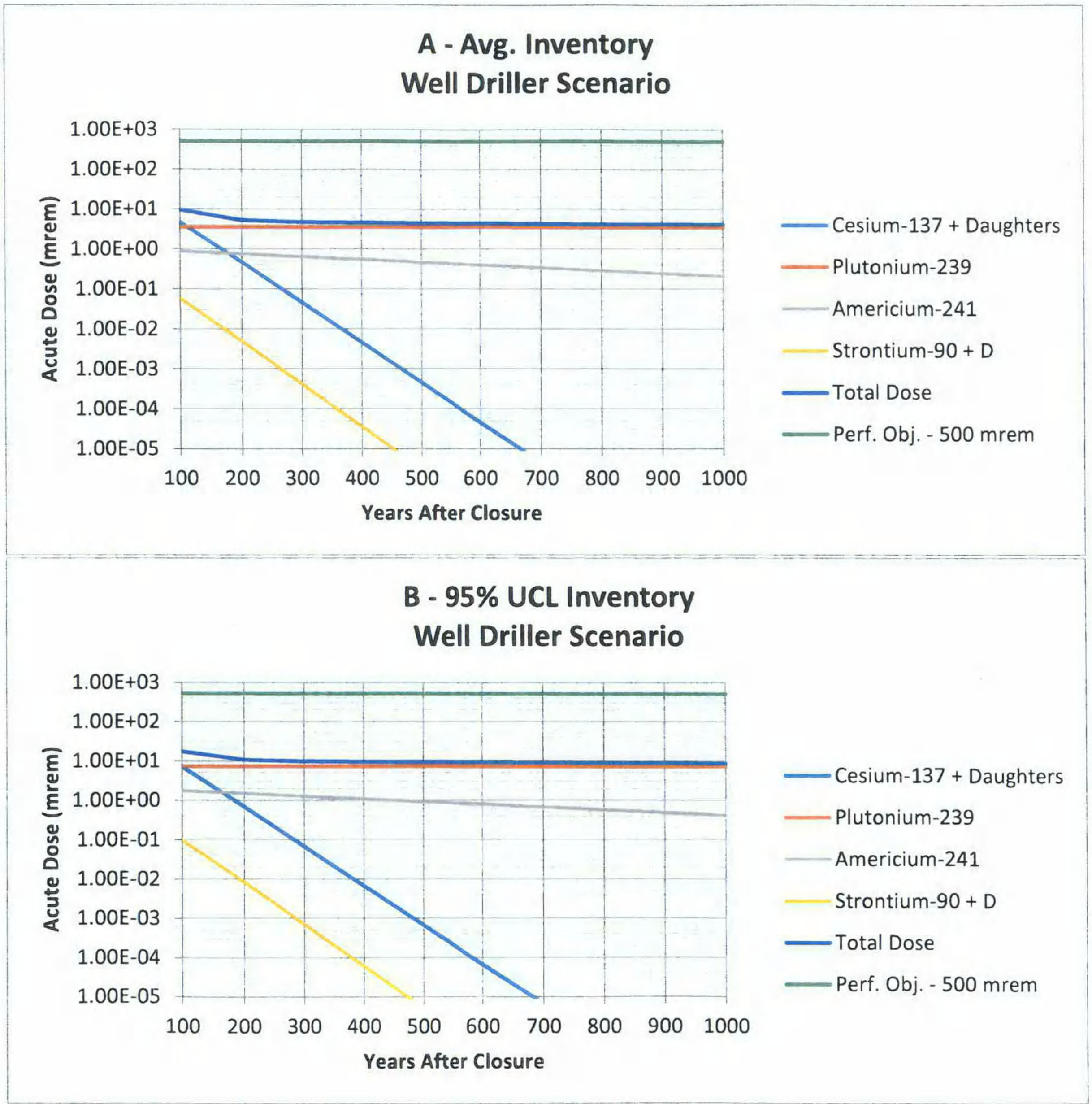
Table D-5. Well Driller Scenario Doses (mrem) for Single-Shell Tank 241-C-102 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways.

Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
Europium-155	1.06E-09	3.91E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-228 + D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	4.31E-02	6.03E-02	7.67E-02	9.25E-02	1.08E-01	1.22E-01	1.36E-01	1.49E-01	1.61E-01	1.73E-01
Thorium-232	3.61E-03	3.61E-03	3.61E-03	3.61E-03	3.61E-03	3.61E-03	3.61E-03	3.61E-03	3.61E-03	3.61E-03
Uranium-233	3.06E-03	4.23E-03	5.39E-03	6.53E-03	7.67E-03	8.80E-03	9.91E-03	1.10E-02	1.21E-02	1.32E-02
Uranium-234	1.06E-03	1.08E-03	1.10E-03	1.13E-03	1.17E-03	1.22E-03	1.26E-03	1.32E-03	1.38E-03	1.44E-03
Uranium-235 + D	6.48E-04	6.66E-04	6.83E-04	7.01E-04	7.18E-04	7.35E-04	7.53E-04	7.70E-04	7.87E-04	8.04E-04
Uranium-236	2.71E-05	2.71E-05	2.71E-05	2.71E-05	2.71E-05	2.71E-05	2.71E-05	2.71E-05	2.71E-05	2.71E-05
Neptunium-237 + D	8.15E-04	8.15E-04	8.15E-04	8.15E-04	8.15E-04	8.15E-04	8.15E-04	8.15E-04	8.15E-04	8.15E-04
Plutonium-238	2.02E-02	9.17E-03	4.16E-03	1.89E-03	8.57E-04	3.90E-04	1.77E-04	8.12E-05	3.75E-05	1.78E-05
Uranium-238 + D	3.10E-03	3.10E-03	3.10E-03	3.10E-03	3.10E-03	3.10E-03	3.11E-03	3.11E-03	3.11E-03	3.11E-03
Plutonium-239	7.34E+00	7.32E+00	7.30E+00	7.27E+00	7.25E+00	7.23E+00	7.21E+00	7.19E+00	7.17E+00	7.15E+00
Plutonium-240	7.78E-01	7.70E-01	7.62E-01	7.54E-01	7.46E-01	7.38E-01	7.30E-01	7.23E-01	7.15E-01	7.08E-01
Americium-241	1.72E+00	1.46E+00	1.25E+00	1.06E+00	9.05E-01	7.71E-01	6.57E-01	5.60E-01	4.77E-01	4.07E-01
Plutonium-241 + D	9.34E-02	7.97E-02	6.79E-02	5.79E-02	4.93E-02	4.20E-02	3.58E-02	3.05E-02	2.60E-02	2.22E-02

Table D-5. Well Driller Scenario Doses (mrem) for Single-Shell Tank 241-C-102 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways.

Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
Curium-242	1.31E-06	5.96E-07	2.71E-07	1.23E-07	5.58E-08	2.53E-08	1.15E-08	5.26E-09	2.42E-09	1.13E-09
Plutonium-242	1.04E-05	1.04E-05	1.04E-05	1.04E-05	1.04E-05	1.04E-05	1.04E-05	1.04E-05	1.04E-05	1.04E-05
Curium-243	1.69E-07	1.80E-08	4.73E-09	3.56E-09	3.45E-09	3.43E-09	3.42E-09	3.41E-09	3.40E-09	3.39E-09
Curium-244	4.17E-07	1.56E-07	1.49E-07	1.47E-07	1.45E-07	1.44E-07	1.42E-07	1.41E-07	1.39E-07	1.38E-07
Tritium	6.97E-11	2.52E-13	9.13E-16	3.30E-18	1.20E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cobalt-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nickel-63	1.71E-03	8.55E-04	4.28E-04	2.14E-04	1.07E-04	5.36E-05	2.68E-05	1.34E-05	6.71E-06	3.36E-06
Selenium-79	2.01E-07	2.01E-07	2.01E-07	2.01E-07	2.01E-07	2.01E-07	2.01E-07	2.01E-07	2.01E-07	2.01E-07
Strontium-90 + D	9.89E-02	8.43E-03	7.18E-04	6.12E-05	5.22E-06	4.45E-07	3.79E-08	3.23E-09	2.75E-10	2.35E-11
Yttrium-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	1.38E-05	1.38E-05	1.38E-05	1.38E-05	1.38E-05	1.38E-05	1.38E-05	1.38E-05	1.38E-05	1.38E-05
Total Dose	**1.70E+01**	**1.04E+01**	**9.57E+00**	**9.30E+00**	**9.12E+00**	**8.96E+00**	**8.83E+00**	**8.71E+00**	**8.61E+00**	**8.52E+00**

Figure D-1. Comparison of Well Driller Scenario Doses (mrem) with Performance Objective for Acute Exposure for Key Analytes – A) Average Inventory and B) 95% Upper Confidence Level Inventory in Residual Wastes within Single-Shell Tank 241-C-102.



UCL = upper confidence level

Table D-6. Rural Pasture Doses (mrem/y) for Single-Shell Tank 241-C-102 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways.

Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
A – Average Inventory										
Antimony-125	9.27E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tin-126	1.38E-03	1.38E-03	1.38E-03	1.38E-03	1.38E-03	1.38E-03	1.38E-03	1.38E-03	1.38E-03	1.38E-03
Iodine-129	4.85E-05	4.85E-05	4.85E-05	4.85E-05	4.85E-05	4.85E-05	4.85E-05	4.85E-05	4.85E-05	4.85E-05
Cesium-137 + Daughters	1.26E+00	1.25E-01	1.24E-02	1.23E-03	1.22E-04	1.21E-05	1.20E-06	1.19E-07	1.18E-08	1.17E-09
Barium-137m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	1.50E-05	1.48E-05	1.46E-05	1.45E-05	1.43E-05	1.41E-05	1.40E-05	1.38E-05	1.36E-05	1.35E-05
Europium-152	1.77E-04	9.75E-07	5.38E-09	2.97E-11	1.64E-13	1.64E-15	7.38E-16	7.33E-16	7.33E-16	7.33E-16
Europium-154	2.28E-06	7.16E-10	2.25E-13	7.04E-17	2.21E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	3.02E-11	1.12E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-228 + D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	3.47E-03	4.69E-03	5.86E-03	6.98E-03	8.05E-03	9.08E-03	1.01E-02	1.10E-02	1.19E-02	1.27E-02
Thorium-232	3.51E-04	3.51E-04	3.51E-04	3.51E-04	3.51E-04	3.51E-04	3.51E-04	3.51E-04	3.51E-04	3.51E-04
Uranium-233	7.00E-04	8.50E-04	9.99E-04	1.15E-03	1.29E-03	1.44E-03	1.58E-03	1.72E-03	1.86E-03	2.00E-03
Uranium-234	3.10E-04	3.13E-04	3.16E-04	3.20E-04	3.24E-04	3.29E-04	3.34E-04	3.41E-04	3.47E-04	3.54E-04

Table D-6. Rural Pasture Doses (mrem/y) for Single-Shell Tank 241-C-102 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways.

Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
Uranium-235 + D	4.53E-05	4.76E-05	4.99E-05	5.21E-05	5.44E-05	5.67E-05	5.90E-05	6.12E-05	6.35E-05	6.58E-05
Uranium-236	8.23E-06	8.23E-06	8.23E-06	8.23E-06	8.23E-06	8.23E-06	8.23E-06	8.23E-06	8.23E-06	8.23E-06
Neptunium-237 + D	1.05E-04	1.05E-04	1.05E-04	1.05E-04	1.05E-04	1.05E-04	1.05E-04	1.05E-04	1.05E-04	1.05E-04
Plutonium-238	3.10E-03	1.41E-03	6.39E-04	2.90E-04	1.32E-04	6.00E-05	2.74E-05	1.26E-05	5.91E-06	2.88E-06
Uranium-238 + D	4.13E-04	4.13E-04	4.13E-04	4.13E-04	4.13E-04	4.14E-04	4.14E-04	4.14E-04	4.14E-04	4.14E-04
Plutonium-239	1.02E+00	1.02E+00	1.02E+00	1.02E+00	1.01E+00	1.01E+00	1.01E+00	1.00E+00	1.00E+00	9.99E-01
Plutonium-240	1.08E-01	1.07E-01	1.06E-01	1.05E-01	1.04E-01	1.03E-01	1.02E-01	1.01E-01	9.97E-02	9.87E-02
Americium-241	2.39E-01	2.03E-01	1.73E-01	1.48E-01	1.26E-01	1.07E-01	9.13E-02	7.78E-02	6.63E-02	5.65E-02
Plutonium-241 + D	1.29E-02	1.10E-02	9.39E-03	8.00E-03	6.81E-03	5.81E-03	4.95E-03	4.22E-03	3.59E-03	3.06E-03
Curium-242	1.24E-07	5.63E-08	2.56E-08	1.16E-08	5.27E-09	2.40E-09	1.10E-09	5.04E-10	2.35E-10	1.14E-10
Plutonium-242	1.45E-06	1.44E-06	1.44E-06	1.44E-06	1.44E-06	1.44E-06	1.44E-06	1.44E-06	1.44E-06	1.44E-06
Curium-243	1.84E-08	2.07E-09	6.33E-10	5.06E-10	4.93E-10	4.91E-10	4.90E-10	4.88E-10	4.87E-10	4.85E-10
Curium-244	6.03E-08	2.24E-08	2.14E-08	2.11E-08	2.09E-08	2.07E-08	2.05E-08	2.02E-08	2.00E-08	1.98E-08
Tritium	8.63E-10	3.12E-12	1.13E-14	4.09E-17	1.48E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cobalt-60	3.63E-09	7.07E-15	1.38E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table D-6. Rural Pasture Doses (mrem/y) for Single-Shell Tank 241-C-102 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways.

Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
Nickel-63	2.94E-02	1.47E-02	7.36E-03	3.68E-03	1.84E-03	9.21E-04	4.61E-04	2.31E-04	1.15E-04	5.78E-05
Selenium-79	7.51E-07	7.51E-07	7.51E-07	7.51E-07	7.51E-07	7.50E-07	7.50E-07	7.50E-07	7.50E-07	7.50E-07
Strontium-90 + D	3.35E+00	2.86E-01	2.44E-02	2.08E-03	1.77E-04	1.51E-05	1.29E-06	1.10E-07	9.34E-09	7.96E-10
Yttrium-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	1.47E-03	1.47E-03	1.47E-03	1.47E-03	1.47E-03	1.47E-03	1.47E-03	1.47E-03	1.47E-03	1.47E-03
Total Dose	**6.04E+00**	**1.78E+00**	**1.36E+00**	**1.30E+00**	**1.27E+00**	**1.24E+00**	**1.22E+00**	**1.20E+00**	**1.19E+00**	**1.18E+00**
B – 95% Upper Confidence Level Inventory										
Antimony-125	2.78E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tin-126	4.14E-03	4.14E-03	4.14E-03	4.14E-03	4.14E-03	4.14E-03	4.13E-03	4.13E-03	4.13E-03	4.13E-03
Iodine-129	6.76E-05	6.76E-05	6.76E-05	6.76E-05	6.76E-05	6.76E-05	6.76E-05	6.76E-05	6.76E-05	6.76E-05
Cesium-137 + Daughters	1.84E+00	1.83E-01	1.81E-02	1.80E-03	1.78E-04	1.77E-05	1.76E-06	1.74E-07	1.73E-08	1.71E-09
Barium-137m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	1.88E-05	1.85E-05	1.83E-05	1.81E-05	1.79E-05	1.77E-05	1.74E-05	1.72E-05	1.70E-05	1.68E-05
Europium-152	5.30E-04	2.93E-06	1.61E-08	8.91E-11	4.94E-13	4.91E-15	2.21E-15	2.20E-15	2.20E-15	2.20E-15
Europium-154	6.83E-06	2.14E-09	6.72E-13	2.11E-16	6.61E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

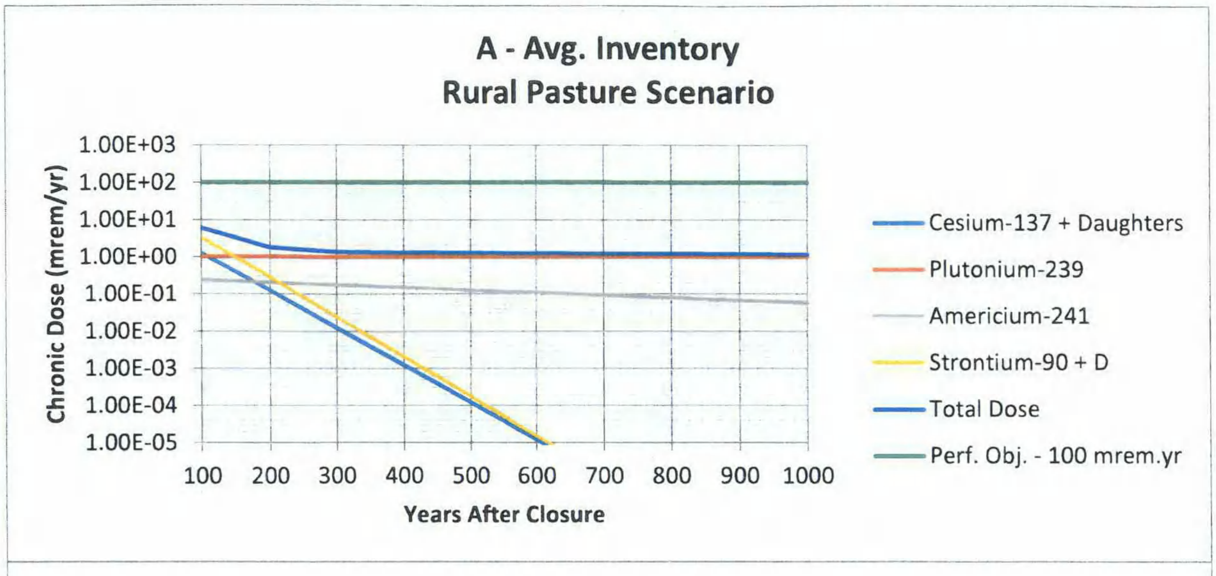
Table D-6. Rural Pasture Doses (mrem/y) for Single-Shell Tank 241-C-102 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways.

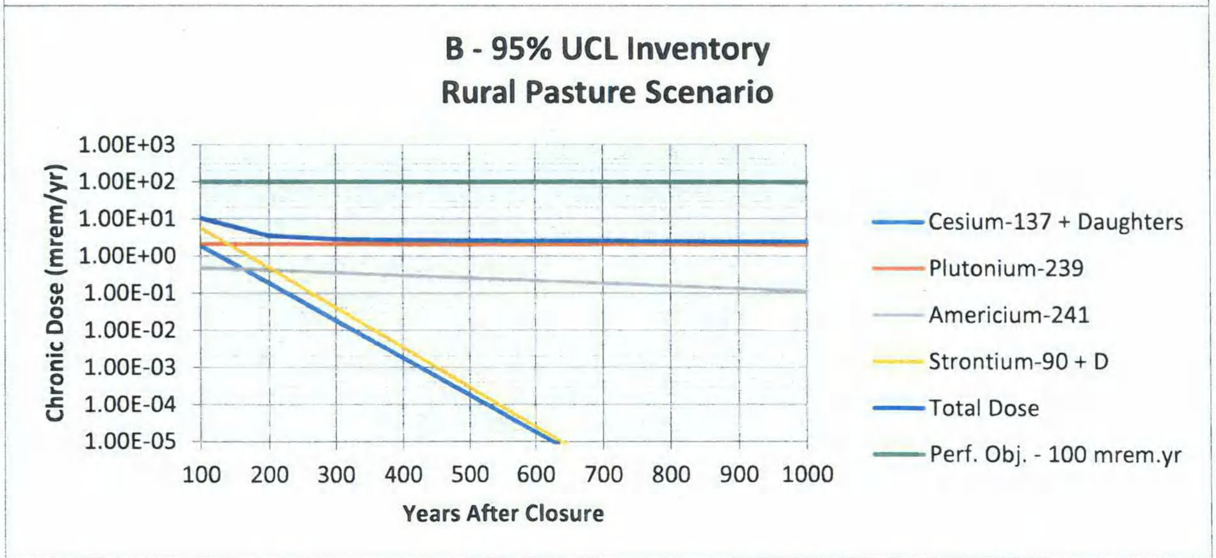
Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
Europium-155	9.07E-11	3.35E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-228 + D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	1.04E-02	1.41E-02	1.76E-02	2.10E-02	2.42E-02	2.73E-02	3.03E-02	3.31E-02	3.58E-02	3.83E-02
Thorium-232	6.54E-04	6.54E-04	6.54E-04	6.54E-04	6.54E-04	6.54E-04	6.54E-04	6.54E-04	6.54E-04	6.54E-04
Uranium-233	1.24E-03	1.51E-03	1.78E-03	2.04E-03	2.30E-03	2.56E-03	2.81E-03	3.06E-03	3.31E-03	3.56E-03
Uranium-234	6.07E-04	6.11E-04	6.17E-04	6.24E-04	6.33E-04	6.43E-04	6.53E-04	6.65E-04	6.79E-04	6.93E-04
Uranium-235 + D	8.78E-05	9.23E-05	9.67E-05	1.01E-04	1.06E-04	1.10E-04	1.14E-04	1.19E-04	1.23E-04	1.28E-04
Uranium-236	1.58E-05	1.58E-05	1.58E-05	1.58E-05	1.58E-05	1.58E-05	1.58E-05	1.58E-05	1.58E-05	1.58E-05
Neptunium-237 + D	1.73E-04	1.73E-04	1.73E-04	1.73E-04	1.73E-04	1.73E-04	1.73E-04	1.73E-04	1.73E-04	1.73E-04
Plutonium-238	5.74E-03	2.60E-03	1.18E-03	5.36E-04	2.44E-04	1.11E-04	5.06E-05	2.33E-05	1.09E-05	5.32E-06
Uranium-238 + D	8.02E-04	8.02E-04	8.02E-04	8.02E-04	8.02E-04	8.02E-04	8.03E-04	8.03E-04	8.03E-04	8.03E-04
Plutonium-239	2.09E+00	2.08E+00	2.08E+00	2.07E+00	2.07E+00	2.06E+00	2.05E+00	2.05E+00	2.04E+00	2.04E+00
Plutonium-240	2.22E-01	2.19E-01	2.17E-01	2.15E-01	2.12E-01	2.10E-01	2.08E-01	2.06E-01	2.04E-01	2.01E-01
Americium-241	4.73E-01	4.03E-01	3.43E-01	2.93E-01	2.49E-01	2.12E-01	1.81E-01	1.54E-01	1.31E-01	1.12E-01
Plutonium-241 + D	2.57E-02	2.20E-02	1.87E-02	1.59E-02	1.36E-02	1.16E-02	9.86E-03	8.40E-03	7.16E-03	6.10E-03

Table D-6. Rural Pasture Doses (mrem/y) for Single-Shell Tank 241-C-102 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways.

Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
Curium-242	3.73E-07	1.69E-07	7.68E-08	3.49E-08	1.58E-08	7.21E-09	3.29E-09	1.51E-09	7.07E-10	3.41E-10
Plutonium-242	2.96E-06	2.96E-06	2.96E-06	2.96E-06	2.96E-06	2.96E-06	2.96E-06	2.96E-06	2.96E-06	2.95E-06
Curium-243	3.64E-08	4.10E-09	1.25E-09	1.00E-09	9.77E-10	9.73E-10	9.70E-10	9.67E-10	9.64E-10	9.61E-10
Curium-244	1.20E-07	4.44E-08	4.23E-08	4.19E-08	4.14E-08	4.10E-08	4.05E-08	4.01E-08	3.97E-08	3.93E-08
Tritium	2.59E-09	9.37E-12	3.39E-14	1.23E-16	4.44E-19	1.61E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cobalt-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nickel-63	4.55E-02	2.27E-02	1.14E-02	5.70E-03	2.85E-03	1.43E-03	7.13E-04	3.57E-04	1.79E-04	8.94E-05
Selenium-79	9.59E-07	9.59E-07	9.59E-07	9.59E-07	9.59E-07	9.59E-07	9.59E-07	9.59E-07	9.59E-07	9.59E-07
Strontium-90 + D	5.71E+00	4.87E-01	4.15E-02	3.53E-03	3.01E-04	2.57E-05	2.19E-06	1.86E-07	1.59E-08	1.35E-09
Yttrium-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	2.52E-03	2.52E-03	2.51E-03	2.51E-03	2.51E-03	2.51E-03	2.51E-03	2.51E-03	2.51E-03	2.51E-03
Total Dose	**1.04E+01**	**3.45E+00**	**2.76E+00**	**2.64E+00**	**2.58E+00**	**2.53E+00**	**2.49E+00**	**2.46E+00**	**2.43E+00**	**2.41E+00**

Figure D-2. Comparison of Rural Pasture Scenario Doses with Performance Objective for Chronic Exposure for Key Analytes within A) Average Inventory and B) 95% Upper Confidence Level Inventory Estimated for Residual Wastes in Single-Shell Tank 241-C-102.





UCL = upper confidence level

Table D-7. Suburban Garden Doses (mrem/y) for Single-Shell Tank 241-C-102 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2007) and Pathways.

Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
A – Average Inventory										
Antimony-125	9.00E-15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tin-126	1.33E-02	1.33E-02	1.33E-02	1.33E-02	1.33E-02	1.33E-02	1.33E-02	1.33E-02	1.32E-02	1.32E-02
Iodine-129	2.41E-04	2.41E-04	2.41E-04	2.41E-04	2.41E-04	2.41E-04	2.41E-04	2.41E-04	2.41E-04	2.41E-04
Cesium-137 + Daughters	1.22E+01	1.21E+00	1.20E-01	1.19E-02	1.18E-03	1.18E-04	1.17E-05	1.16E-06	1.15E-07	1.14E-08
Barium-137m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	2.63E-04	2.60E-04	2.57E-04	2.54E-04	2.51E-04	2.48E-04	2.45E-04	2.42E-04	2.39E-04	2.36E-04
Europium-152	1.70E-03	9.37E-06	5.17E-08	2.85E-10	1.58E-12	1.91E-14	1.04E-14	1.04E-14	1.04E-14	1.04E-14
Europium-154	2.20E-05	6.89E-09	2.16E-12	6.78E-16	2.13E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	2.97E-10	1.10E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-228 + D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	5.93E-02	8.76E-02	1.15E-01	1.41E-01	1.65E-01	1.89E-01	2.12E-01	2.34E-01	2.54E-01	2.74E-01
Thorium-232	4.06E-03	4.06E-03	4.06E-03	4.06E-03	4.06E-03	4.06E-03	4.06E-03	4.06E-03	4.06E-03	4.06E-03
Uranium-233	2.69E-02	2.90E-02	3.11E-02	3.31E-02	3.52E-02	3.72E-02	3.92E-02	4.12E-02	4.32E-02	4.51E-02
Uranium-234	1.47E-02	1.48E-02	1.48E-02	1.49E-02	1.50E-02	1.51E-02	1.52E-02	1.53E-02	1.55E-02	1.56E-02

Table D-7. Suburban Garden Doses (mrem/y) for Single-Shell Tank 241-C-102 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2007) and Pathways.

Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
Uranium-235 + D	9.39E-04	9.88E-04	1.04E-03	1.08E-03	1.13E-03	1.18E-03	1.23E-03	1.28E-03	1.33E-03	1.37E-03
Uranium-236	3.92E-04	3.92E-04	3.92E-04	3.92E-04	3.92E-04	3.92E-04	3.92E-04	3.92E-04	3.92E-04	3.92E-04
Neptunium-237 + D	7.23E-03	7.23E-03	7.23E-03	7.23E-03	7.23E-03	7.23E-03	7.23E-03	7.23E-03	7.23E-03	7.23E-03
Plutonium-238	6.86E-02	3.12E-02	1.41E-02	6.42E-03	2.92E-03	1.33E-03	6.14E-04	2.87E-04	1.39E-04	7.16E-05
Uranium-238 + D	1.54E-02	1.54E-02	1.54E-02	1.54E-02	1.54E-02	1.54E-02	1.54E-02	1.54E-02	1.55E-02	1.55E-02
Plutonium-239	2.27E+01	2.27E+01	2.26E+01	2.25E+01	2.25E+01	2.24E+01	2.23E+01	2.23E+01	2.22E+01	2.22E+01
Plutonium-240	2.41E+00	2.38E+00	2.36E+00	2.33E+00	2.31E+00	2.28E+00	2.26E+00	2.24E+00	2.21E+00	2.19E+00
Americium-241	5.23E+00	4.45E+00	3.79E+00	3.23E+00	2.76E+00	2.35E+00	2.00E+00	1.71E+00	1.46E+00	1.24E+00
Plutonium-241 + D	2.83E-01	2.41E-01	2.06E-01	1.75E-01	1.49E-01	1.27E-01	1.08E-01	9.25E-02	7.88E-02	6.72E-02
Curium-242	2.75E-06	1.25E-06	5.66E-07	2.57E-07	1.17E-07	5.34E-08	2.45E-08	1.15E-08	5.52E-09	2.83E-09
Plutonium-242	3.20E-05	3.20E-05	3.20E-05	3.20E-05	3.19E-05	3.19E-05	3.19E-05	3.19E-05	3.19E-05	3.19E-05
Curium-243	3.52E-07	4.09E-08	1.36E-08	1.12E-08	1.09E-08	1.09E-08	1.08E-08	1.08E-08	1.08E-08	1.08E-08
Curium-244	1.30E-06	4.96E-07	4.74E-07	4.69E-07	4.64E-07	4.59E-07	4.54E-07	4.49E-07	4.44E-07	4.40E-07
Tritium	7.54E-09	2.73E-11	9.87E-14	3.57E-16	1.29E-18	4.68E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cobalt-60	3.64E-08	7.08E-14	1.38E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table D-7. Suburban Garden Doses (mrem/y) for Single-Shell Tank 241-C-102 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2007) and Pathways.

Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
Nickel-63	1.99E-01	9.97E-02	4.99E-02	2.50E-02	1.25E-02	6.25E-03	3.13E-03	1.56E-03	7.83E-04	3.92E-04
Selenium-79	1.22E-05	1.22E-05	1.22E-05	1.22E-05	1.22E-05	1.22E-05	1.22E-05	1.22E-05	1.22E-05	1.22E-05
Strontium-90 + D	4.76E+01	4.05E+00	3.46E-01	2.95E-02	2.51E-03	2.14E-04	1.82E-05	1.55E-06	1.32E-07	1.13E-08
Yttrium-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	1.12E-01	1.12E-01	1.12E-01	1.12E-01	1.12E-01	1.12E-01	1.12E-01	1.12E-01	1.12E-01	1.12E-01
Total Dose	**9.10E+01**	**3.54E+01**	**2.98E+01**	**2.87E+01**	**2.81E+01**	**2.76E+01**	**2.71E+01**	**2.68E+01**	**2.64E+01**	**2.61E+01**
B – 95% Upper Confidence Level Inventory										
Antimony-125	2.70E-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tin-126	3.99E-02	3.99E-02	3.98E-02	3.98E-02	3.98E-02	3.98E-02	3.98E-02	3.98E-02	3.98E-02	3.98E-02
Iodine-129	3.36E-04	3.36E-04	3.36E-04	3.36E-04	3.36E-04	3.36E-04	3.36E-04	3.36E-04	3.36E-04	3.36E-04
Cesium-137 + Daughters	1.79E+01	1.77E+00	1.76E-01	1.74E-02	1.73E-03	1.72E-04	1.70E-05	1.69E-06	1.67E-07	1.66E-08
Barium-137m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	3.29E-04	3.25E-04	3.21E-04	3.17E-04	3.13E-04	3.10E-04	3.06E-04	3.02E-04	2.99E-04	2.95E-04
Europium-152	5.10E-03	2.81E-05	1.55E-07	8.56E-10	4.75E-12	5.72E-14	3.13E-14	3.12E-14	3.12E-14	3.12E-14
Europium-154	6.57E-05	2.06E-08	6.46E-12	2.03E-15	6.36E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

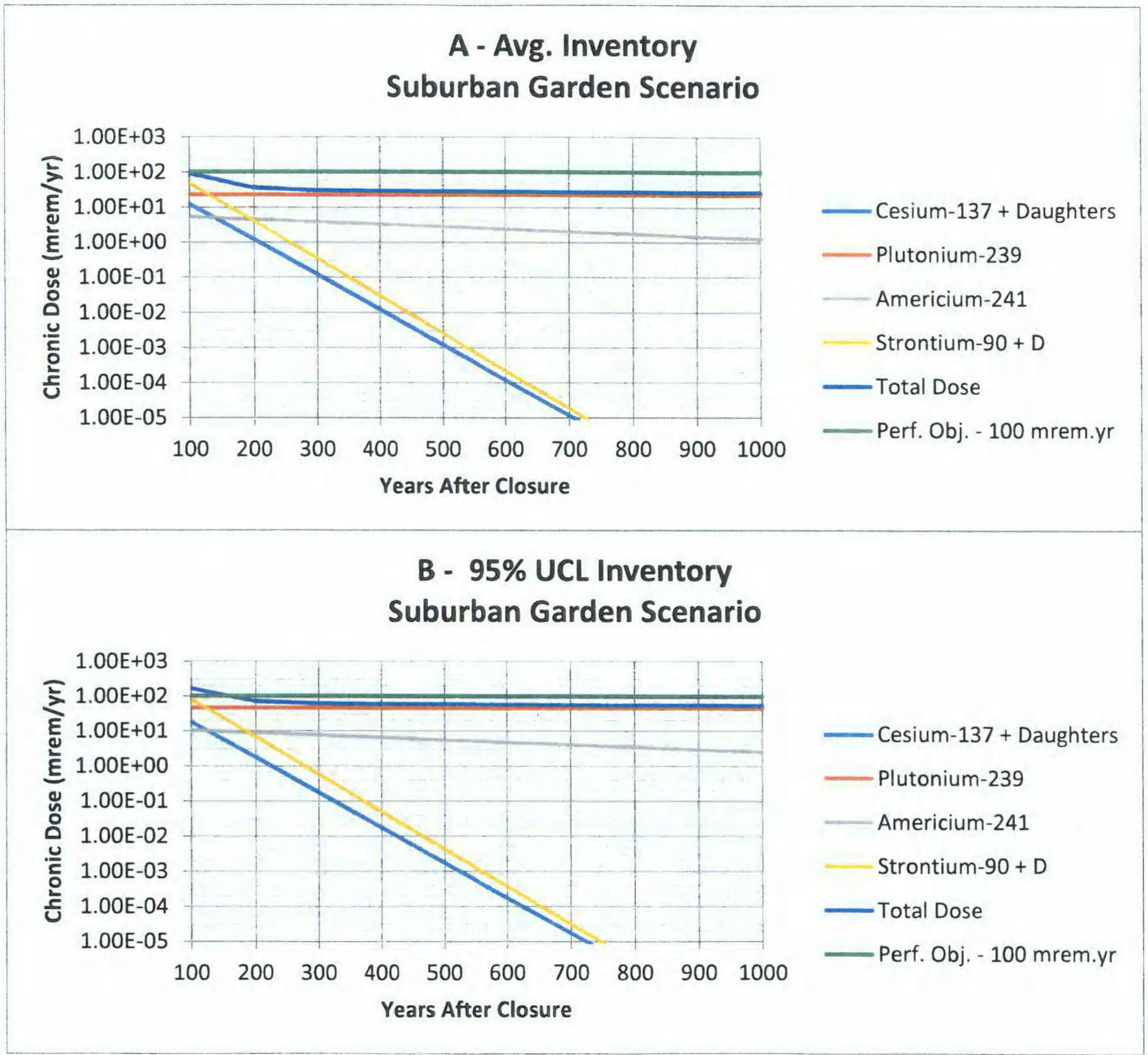
Table D-7. Suburban Garden Doses (mrem/y) for Single-Shell Tank 241-C-102 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2007) and Pathways.

Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
Europium-155	8.91E-10	3.29E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-228 + D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	1.78E-01	2.63E-01	3.45E-01	4.23E-01	4.98E-01	5.69E-01	6.37E-01	7.03E-01	7.65E-01	8.25E-01
Thorium-232	7.58E-03	7.58E-03	7.58E-03	7.58E-03	7.58E-03	7.58E-03	7.58E-03	7.58E-03	7.58E-03	7.58E-03
Uranium-233	4.77E-02	5.15E-02	5.52E-02	5.89E-02	6.25E-02	6.61E-02	6.97E-02	7.32E-02	7.67E-02	8.02E-02
Uranium-234	2.88E-02	2.88E-02	2.89E-02	2.91E-02	2.93E-02	2.94E-02	2.97E-02	2.99E-02	3.02E-02	3.05E-02
Uranium-235 + D	1.82E-03	1.92E-03	2.01E-03	2.11E-03	2.20E-03	2.29E-03	2.39E-03	2.48E-03	2.57E-03	2.67E-03
Uranium-236	7.52E-04	7.52E-04	7.52E-04	7.52E-04	7.52E-04	7.52E-04	7.52E-04	7.52E-04	7.52E-04	7.52E-04
Neptunium-237 + D	1.20E-02	1.20E-02	1.20E-02	1.20E-02	1.20E-02	1.20E-02	1.20E-02	1.20E-02	1.20E-02	1.20E-02
Plutonium-238	1.27E-01	5.76E-02	2.61E-02	1.19E-02	5.40E-03	2.47E-03	1.13E-03	5.31E-04	2.57E-04	1.32E-04
Uranium-238 + D	2.99E-02	2.99E-02	2.99E-02	2.99E-02	2.99E-02	3.00E-02	3.00E-02	3.00E-02	3.00E-02	3.00E-02
Plutonium-239	4.63E+01	4.62E+01	4.61E+01	4.59E+01	4.58E+01	4.57E+01	4.55E+01	4.54E+01	4.53E+01	4.52E+01
Plutonium-240	4.91E+00	4.86E+00	4.81E+00	4.76E+00	4.71E+00	4.66E+00	4.61E+00	4.56E+00	4.52E+00	4.47E+00
Americium-241	1.04E+01	8.83E+00	7.52E+00	6.41E+00	5.46E+00	4.66E+00	3.97E+00	3.38E+00	2.88E+00	2.46E+00
Plutonium-241 + D	5.63E-01	4.81E-01	4.10E-01	3.49E-01	2.98E-01	2.54E-01	2.16E-01	1.84E-01	1.57E-01	1.34E-01

Table D-7. Suburban Garden Doses (mrem/y) for Single-Shell Tank 241-C-102 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2007) and Pathways.

Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
Curium-242	8.25E-06	3.75E-06	1.70E-06	7.72E-07	3.51E-07	1.60E-07	7.37E-08	3.44E-08	1.66E-08	8.51E-09
Plutonium-242	6.55E-05	6.55E-05	6.54E-05	6.54E-05	6.54E-05	6.54E-05	6.54E-05	6.54E-05	6.54E-05	6.54E-05
Curium-243	6.97E-07	8.11E-08	2.69E-08	2.21E-08	2.16E-08	2.15E-08	2.15E-08	2.14E-08	2.14E-08	2.13E-08
Curium-244	2.58E-06	9.84E-07	9.39E-07	9.29E-07	9.19E-07	9.09E-07	9.00E-07	8.90E-07	8.81E-07	8.71E-07
Tritium	2.26E-08	8.18E-11	2.96E-13	1.07E-15	3.88E-18	1.40E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cobalt-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nickel-63	3.08E-01	1.54E-01	7.72E-02	3.86E-02	1.93E-02	9.67E-03	4.84E-03	2.42E-03	1.21E-03	6.06E-04
Selenium-79	1.56E-05	1.56E-05	1.56E-05	1.56E-05	1.56E-05	1.56E-05	1.56E-05	1.56E-05	1.56E-05	1.56E-05
Strontium-90 + D	8.10E+01	6.90E+00	5.88E-01	5.01E-02	4.27E-03	3.64E-04	3.10E-05	2.65E-06	2.25E-07	1.92E-08
Yttrium-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	1.92E-01	1.92E-01	1.92E-01	1.92E-01	1.91E-01	1.91E-01	1.91E-01	1.91E-01	1.91E-01	1.91E-01
Total Dose	**1.62E+02**	**6.99E+01**	**6.04E+01**	**5.84E+01**	**5.72E+01**	**5.62E+01**	**5.54E+01**	**5.46E+01**	**5.40E+01**	**5.34E+01**

Figure D-3. Comparison of Doses from Suburban Gardener Scenario with Performance Objective for Chronic Exposure for Key Analytes within A) Average Inventory and B) 95% Upper Confidence Level Inventory Estimated for Residual Wastes in Single-Shell Tank 241-C-102.



UCL = upper confidence level

Table D-8. Commercial Farm Doses (mrem/y) for Single-Shell Tank 241-C-102 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways.

Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
A – Average Inventory										
Antimony-125	3.53E-17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tin-126	5.24E-05	5.24E-05	5.24E-05	5.24E-05	5.24E-05	5.24E-05	5.23E-05	5.23E-05	5.23E-05	5.23E-05
Iodine-129	2.23E-08	2.23E-08	2.23E-08	2.23E-08	2.23E-08	2.23E-08	2.23E-08	2.23E-08	2.23E-08	2.23E-08
Cesium-137 + Daughters	2.02E-02	2.00E-03	1.99E-04	1.97E-05	1.96E-06	1.94E-07	1.92E-08	1.91E-09	1.89E-10	1.88E-11
Barium-137m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	7.27E-10	7.18E-10	7.09E-10	7.01E-10	6.92E-10	6.84E-10	6.76E-10	6.68E-10	6.60E-10	6.52E-10
Europium-152	6.74E-06	3.72E-08	2.05E-10	1.13E-12	6.27E-15	6.01E-17	2.58E-17	2.56E-17	2.56E-17	2.56E-17
Europium-154	8.71E-08	2.73E-11	8.57E-15	2.69E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	1.15E-12	4.25E-19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-228 + D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	9.90E-05	1.25E-04	1.50E-04	1.75E-04	1.98E-04	2.20E-04	2.41E-04	2.61E-04	2.80E-04	2.98E-04
Thorium-232	1.04E-05	1.04E-05	1.04E-05	1.04E-05	1.04E-05	1.04E-05	1.04E-05	1.04E-05	1.04E-05	1.04E-05
Uranium-233	1.20E-05	1.71E-05	2.21E-05	2.70E-05	3.19E-05	3.68E-05	4.16E-05	4.64E-05	5.11E-05	5.58E-05
Uranium-234	3.45E-06	3.51E-06	3.59E-06	3.69E-06	3.80E-06	3.92E-06	4.05E-06	4.20E-06	4.36E-06	4.53E-06
Uranium-235 + D	1.36E-06	1.43E-06	1.49E-06	1.56E-06	1.62E-06	1.69E-06	1.75E-06	1.82E-06	1.88E-06	1.95E-06

Table D-8. Commercial Farm Doses (mrem/y) for Single-Shell Tank 241-C-102 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways.

Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
Uranium-236	9.01E-08	9.01E-08	9.01E-08	9.01E-08	9.01E-08	9.01E-08	9.01E-08	9.01E-08	9.01E-08	9.01E-08
Neptunium-237 + D	3.13E-06	3.13E-06	3.13E-06	3.13E-06	3.13E-06	3.14E-06	3.14E-06	3.14E-06	3.14E-06	3.14E-06
Plutonium-238	8.75E-05	3.97E-05	1.80E-05	8.18E-06	3.71E-06	1.69E-06	7.67E-07	3.50E-07	1.61E-07	7.57E-08
Uranium-238 + D	7.58E-06	7.58E-06	7.58E-06	7.58E-06	7.58E-06	7.58E-06	7.58E-06	7.59E-06	7.59E-06	7.59E-06
Plutonium-239	2.89E-02	2.88E-02	2.87E-02	2.86E-02	2.85E-02	2.85E-02	2.84E-02	2.83E-02	2.82E-02	2.81E-02
Plutonium-240	3.06E-03	3.02E-03	2.99E-03	2.96E-03	2.93E-03	2.90E-03	2.87E-03	2.84E-03	2.81E-03	2.78E-03
Americium-241	6.75E-03	5.76E-03	4.90E-03	4.18E-03	3.56E-03	3.03E-03	2.59E-03	2.20E-03	1.88E-03	1.60E-03
Plutonium-241 + D	3.66E-04	3.12E-04	2.66E-04	2.26E-04	1.93E-04	1.64E-04	1.40E-04	1.19E-04	1.02E-04	8.67E-05
Curium-242	3.50E-09	1.59E-09	7.21E-10	3.27E-10	1.49E-10	6.75E-11	3.07E-11	1.40E-11	6.42E-12	2.99E-12
Plutonium-242	4.08E-08	4.08E-08	4.08E-08	4.08E-08	4.07E-08	4.07E-08	4.07E-08	4.07E-08	4.07E-08	4.07E-08
Curium-243	5.41E-10	6.03E-11	1.80E-11	1.43E-11	1.39E-11	1.38E-11	1.38E-11	1.38E-11	1.37E-11	1.37E-11
Curium-244	1.67E-09	6.31E-10	6.02E-10	5.95E-10	5.89E-10	5.83E-10	5.77E-10	5.71E-10	5.65E-10	5.59E-10
Tritium	3.02E-11	1.09E-13	3.95E-16	1.43E-18	5.18E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cobalt-60	1.38E-10	2.69E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nickel-63	6.27E-06	3.14E-06	1.57E-06	7.85E-07	3.93E-07	1.97E-07	9.83E-08	4.92E-08	2.46E-08	1.23E-08
Selenium-79	8.22E-10	8.22E-10	8.22E-10	8.22E-10	8.21E-10	8.21E-10	8.21E-10	8.21E-10	8.21E-10	8.21E-10

Table D-8. Commercial Farm Doses (mrem/y) for Single-Shell Tank 241-C-102 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways.

Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
Strontium-90 + D	2.77E-04	2.36E-05	2.01E-06	1.71E-07	1.46E-08	1.24E-09	1.06E-10	9.04E-12	7.70E-13	6.56E-14
Yttrium-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	3.66E-08	3.66E-08	3.66E-08	3.65E-08	3.65E-08	3.65E-08	3.65E-08	3.65E-08	3.65E-08	3.65E-08
Total Dose	**5.98E-02**	**4.02E-02**	**3.73E-02**	**3.63E-02**	**3.55E-02**	**3.49E-02**	**3.43E-02**	**3.38E-02**	**3.34E-02**	**3.30E-02**
B – 95% Upper Confidence Level Inventory										
Antimony-125	1.06E-16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tin-126	1.57E-04	1.57E-04	1.57E-04	1.57E-04	1.57E-04	1.57E-04	1.57E-04	1.57E-04	1.57E-04	1.57E-04
Iodine-129	3.11E-08	3.11E-08	3.11E-08	3.11E-08	3.11E-08	3.11E-08	3.11E-08	3.11E-08	3.11E-08	3.11E-08
Cesium-137 + Daughters	2.95E-02	2.92E-03	2.90E-04	2.88E-05	2.85E-06	2.83E-07	2.81E-08	2.79E-09	2.76E-10	2.74E-11
Barium-137m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbon-14	9.08E-10	8.98E-10	8.87E-10	8.76E-10	8.66E-10	8.55E-10	8.45E-10	8.35E-10	8.25E-10	8.15E-10
Europium-152	2.02E-05	1.12E-07	6.16E-10	3.40E-12	1.88E-14	1.80E-16	7.75E-17	7.69E-17	7.69E-17	7.69E-17
Europium-154	2.61E-07	8.17E-11	2.56E-14	8.04E-18	2.52E-21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Europium-155	3.45E-12	1.28E-18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-228 + D	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Thorium-230	2.98E-04	3.77E-04	4.53E-04	5.25E-04	5.94E-04	6.60E-04	7.24E-04	7.84E-04	8.42E-04	8.98E-04

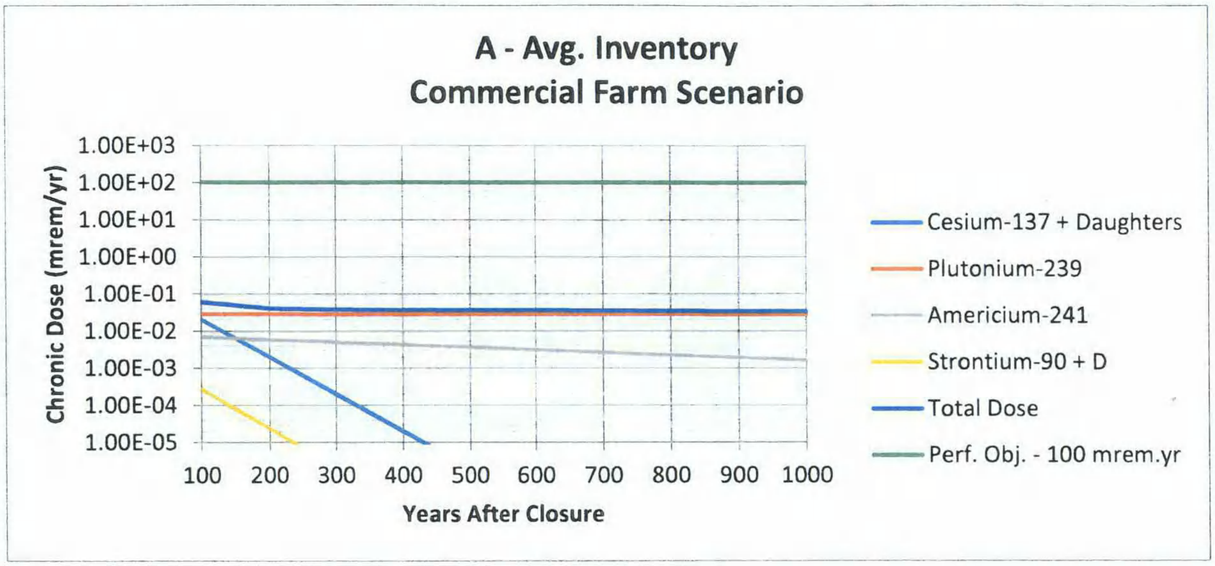
Table D-8. Commercial Farm Doses (mrem/y) for Single-Shell Tank 241-C-102 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways.

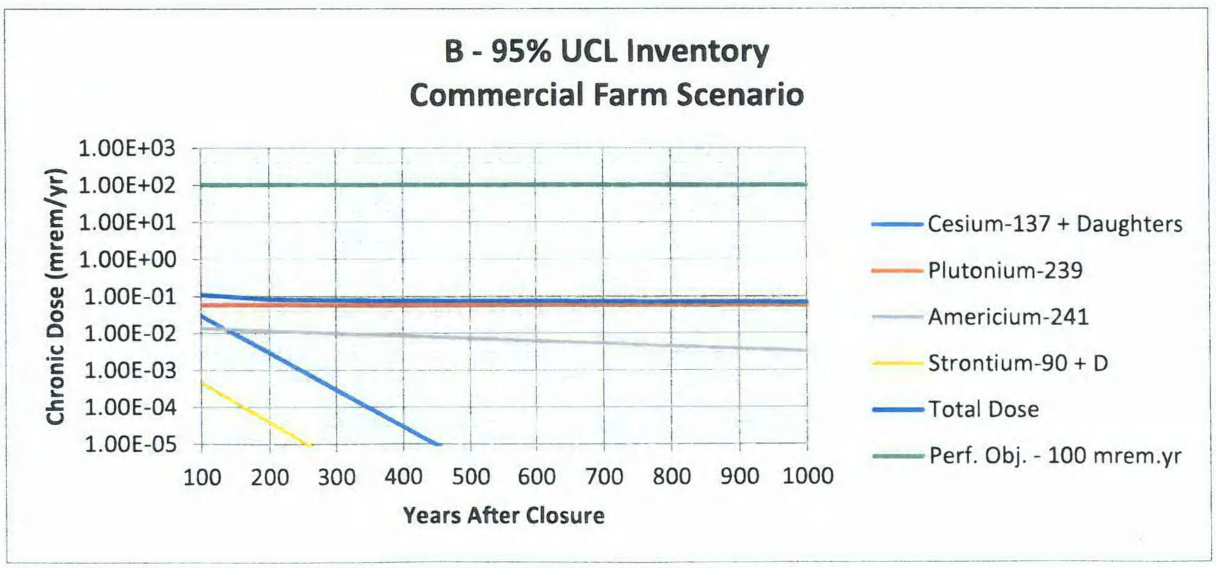
Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
Thorium-232	1.95E-05	1.95E-05	1.95E-05	1.95E-05	1.95E-05	1.95E-05	1.95E-05	1.95E-05	1.95E-05	1.95E-05
Uranium-233	2.14E-05	3.03E-05	3.92E-05	4.81E-05	5.68E-05	6.54E-05	7.40E-05	8.24E-05	9.08E-05	9.91E-05
Uranium-234	6.73E-06	6.86E-06	7.02E-06	7.20E-06	7.42E-06	7.66E-06	7.92E-06	8.21E-06	8.52E-06	8.85E-06
Uranium-235 + D	2.64E-06	2.77E-06	2.90E-06	3.02E-06	3.15E-06	3.27E-06	3.40E-06	3.53E-06	3.65E-06	3.78E-06
Uranium-236	1.73E-07	1.73E-07	1.73E-07	1.73E-07	1.73E-07	1.73E-07	1.73E-07	1.73E-07	1.73E-07	1.73E-07
Neptunium-237 + D	5.19E-06	5.19E-06	5.19E-06	5.19E-06	5.19E-06	5.19E-06	5.19E-06	5.19E-06	5.19E-06	5.19E-06
Plutonium-238	1.62E-04	7.34E-05	3.33E-05	1.51E-05	6.86E-06	3.12E-06	1.42E-06	6.48E-07	2.98E-07	1.40E-07
Uranium-238 + D	1.47E-05	1.47E-05	1.47E-05	1.47E-05	1.47E-05	1.47E-05	1.47E-05	1.47E-05	1.47E-05	1.47E-05
Plutonium-239	5.89E-02	5.87E-02	5.85E-02	5.84E-02	5.82E-02	5.80E-02	5.78E-02	5.77E-02	5.75E-02	5.74E-02
Plutonium-240	6.24E-03	6.18E-03	6.11E-03	6.05E-03	5.98E-03	5.92E-03	5.86E-03	5.80E-03	5.74E-03	5.68E-03
Americium-241	1.34E-02	1.14E-02	9.72E-03	8.28E-03	7.06E-03	6.01E-03	5.12E-03	4.37E-03	3.72E-03	3.17E-03
Plutonium-241 + D	7.28E-04	6.21E-04	5.30E-04	4.51E-04	3.84E-04	3.28E-04	2.79E-04	2.38E-04	2.03E-04	1.73E-04
Curium-242	1.05E-08	4.78E-09	2.17E-09	9.83E-10	4.46E-10	2.03E-10	9.22E-11	4.20E-11	1.93E-11	8.98E-12
Plutonium-242	8.35E-08	8.35E-08	8.35E-08	8.35E-08	8.34E-08	8.34E-08	8.34E-08	8.34E-08	8.34E-08	8.34E-08
Curium-243	1.07E-09	1.19E-10	3.57E-11	2.83E-11	2.76E-11	2.74E-11	2.73E-11	2.73E-11	2.72E-11	2.71E-11
Curium-244	3.31E-09	1.25E-09	1.19E-09	1.18E-09	1.17E-09	1.15E-09	1.14E-09	1.13E-09	1.12E-09	1.11E-09

Table D-8. Commercial Farm Doses (mrem/y) for Single-Shell Tank 241-C-102 Showing Major Constituents for A) Average Inventory and B) 95% Upper Confidence Level Inventory (decayed as of January 2008) and Pathways.

Nuclide	Years After Site Closure (January 1, 2032)									
	100	200	300	400	500	600	700	800	900	1,000
Tritium	9.06E-11	3.28E-13	1.19E-15	4.29E-18	1.55E-20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cobalt-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nickel-63	9.70E-06	4.85E-06	2.43E-06	1.21E-06	6.08E-07	3.04E-07	1.52E-07	7.61E-08	3.81E-08	1.91E-08
Selenium-79	1.05E-09	1.05E-09	1.05E-09	1.05E-09	1.05E-09	1.05E-09	1.05E-09	1.05E-09	1.05E-09	1.05E-09
Strontium-90 + D	4.71E-04	4.01E-05	3.42E-06	2.92E-07	2.48E-08	2.12E-09	1.80E-10	1.54E-11	1.31E-12	1.12E-13
Yttrium-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Technetium-99	6.24E-08	6.24E-08	6.24E-08	6.24E-08	6.23E-08	6.23E-08	6.23E-08	6.23E-08	6.23E-08	6.22E-08
Total Dose	**1.10E-01**	**8.06E-02**	**7.59E-02**	**7.40E-02**	**7.25E-02**	**7.12E-02**	**7.01E-02**	**6.92E-02**	**6.83E-02**	**6.76E-02**

Figure D-4. Comparison of Doses from Commercial Farm Scenario with Performance Objective for Chronic Exposure for Key Analytes within A) Average Inventory and B) 95% Upper Confidence Level Inventory Estimated for Residual Wastes in Single-Shell Tank 241-C-102.





UCL = upper confidence level

Table D-9. Average and 95% Upper Confidence Levels for Waste Residuals within Tank 241-C-102, Soil Cleanup Levels for Method B and C Direct Contact Exposure, and Soil Concentrations Protective of Groundwater.

Analyte	Average Concentration (mg/kg)[a]	95% Upper Confidence Level Concentration (mg/kg)[b]	Soil Cleanup Level (mg/kg) – Direct Contact Method B	Soil Cleanup Level (mg/kg) – Direct Contact Method C	Soil Concentrations (mg/kg) – Protective of Groundwater	Above Detection Limits
Acetate	1.15E+02	1.28E+02	--	--	--	Yes
Aluminum	2.61E+05	2.72E+05	8.00E+04	3.50E+06	4.80E+05	Yes
Ammonia	2.50E+00	2.95E+00	--	--	--	Yes
Barium*	6.35E+00	9.16E+00	--	--	--	Yes
Beryllium*	1.40E+00	1.76E+00	1.60E+02	7.00E+03	6.32E+01	Yes
Butylbenzylphthalate*	1.00E+00	1.29E+00	5.26E+02	6.91E+04	1.29E+01	Yes
Cadmium*	1.17E+00	1.33E+00	8.00E+01	3.50E+03	6.90E-01	Yes
Calcium	1.66E+02	2.10E+02	--	--	--	Yes
Chloride	8.80E+01	1.04E+02	--	--	1.00E+03	Yes
Chromium, Total*	1.17E+02	2.46E+02	1.20E+05	5.25E+06	2.00E+03	Yes
Copper	8.66E+01	1.26E+02	3.20E+03	1.40E+05	2.84E+02	Yes
Cyanide*	4.39E+01	5.59E+01	4.80E+01	2.10E+03	9.70E-01	Yes
Di (2-ethylhexyl) phthalate (DEHP)	3.72E+00	5.97E+00	7.14E+01	9.38E+03	1.34E+01	Yes
Di-n-butylphthalate*	6.60E-01	8.93E-01	8.00E+03	3.50E+05	5.66E+01	Yes
Fluoride	3.02E+03	4.90E+03	4.80E+03	2.10E+05	2.88E+03	Yes

Table D-9. Average and 95% Upper Confidence Levels for Waste Residuals within Tank 241-C-102, Soil Cleanup Levels for Method B and C Direct Contact Exposure, and Soil Concentrations Protective of Groundwater.

Analyte	Average Concentration (mg/kg)[a]	95% Upper Confidence Level Concentration (mg/kg)[b]	Soil Cleanup Level (mg/kg) – Direct Contact Method B	Soil Cleanup Level (mg/kg) – Direct Contact Method C	Soil Concentrations (mg/kg) – Protective of Groundwater	Above Detection Limits
Formate+A2	1.18E+02	1.58E+02	--	--	--	Yes
Hydroxide OH	7.36E+00	1.48E+01	--	--	--	Yes
Iron	1.72E+03	2.68E+03	5.60E+04	2.45E+06	5.64E+03	Yes
Lead*	4.46E+01	6.70E+01	--	1.00E+03	3.00E+03	Yes
Magnesium	6.99E+01	7.65E+01	--	--	--	Yes
Manganese	5.00E+02	1.26E+03	1.12E+04	4.90E+05	5.01E+02	Yes
Mercury*	4.41E+00	1.13E+01	2.40E+01	1.05E+03	2.09E+00	Yes
Molybdenum	2.43E+00	2.77E+00	4.00E+02	1.75E+04	3.23E+01	Yes
Nickel*	6.15E+00	9.42E+00	--	--	--	Yes
Nitrate	5.79E+03	6.85E+03	5.68E+05	2.49E+07	1.80E+02	Yes
Nitrite	2.95E+03	3.42E+03	2.40E+04	1.05E+06	1.32E+01	Yes
Oxalate	1.58E+02	1.79E+02	--	--	--	Yes
Phosphate	7.44E+03	1.42E+04	--	--	--	Yes
Polychlorinated Biphenyls*	2.35E-02	3.97E-02	5.00E-01	6.56E+01	--	Yes
Potassium	1.14E+02	1.59E+02	--	--	--	Yes
Samarium	3.81E+01	6.12E+01	--	--	--	Yes

Table D-9. Average and 95% Upper Confidence Levels for Waste Residuals within Tank 241-C-102, Soil Cleanup Levels for Method B and C Direct Contact Exposure, and Soil Concentrations Protective of Groundwater.

Analyte	Average Concentration (mg/kg)[a]	95% Upper Confidence Level Concentration (mg/kg)[b]	Soil Cleanup Level (mg/kg) – Direct Contact Method B	Soil Cleanup Level (mg/kg) – Direct Contact Method C	Soil Concentrations (mg/kg) – Protective of Groundwater	Above Detection Limits
Selenium*	2.48E-05	3.13E-05	--	--	--	Yes
Silicon	8.97E+02	9.81E+02	--	--	--	Yes
Silver*	5.90E+01	1.16E+02	4.00E+02	1.75E+04	1.36E+01	Yes
Sodium	3.29E+04	3.93E+04	--	--	--	Yes
Strontium	1.11E+01	1.75E+01	4.80E+04	2.10E+06	6.76E+03	Yes
Sulfate	5.91E+02	6.17E+02	--	--	1.00E+03	Yes
Tellurium	9.49E+00	1.02E+01	--	--	--	Yes
Thorium	2.60E+02	4.78E+02	--	--	--	Yes
Tin	2.09E+01	3.21E+01	4.80E+04	2.10E+06	4.80E+04	Yes
Titanium	2.84E+01	4.34E+01	--	--	--	Yes
Tributyl phosphate	4.53E+00	7.86E+00	1.11E+02	1.46E+04	4.96E-01	Yes
Uranium	6.38E+03	1.20E+04	2.40E+02	1.05E+04	2.70E+02	Yes
Vanadium	5.85E+00	9.48E+00	4.00E+02	1.75E+04	1.60E+03	Yes
Zinc	5.67E+01	6.88E+01	2.40E+04	1.05E+06	5.97E+03	Yes
Zirconium	4.16E+02	8.02E+02	--	--	--	Yes
1, 1, 2-Trichloroethylene	1.21E-03	3.58E-03	2.17E+01	1.75E+03	6.29E-03	No

Table D-9. Average and 95% Upper Confidence Levels for Waste Residuals within Tank 241-C-102, Soil Cleanup Levels for Method B and C Direct Contact Exposure, and Soil Concentrations Protective of Groundwater.

Analyte	Average Concentration (mg/kg)[a]	95% Upper Confidence Level Concentration (mg/kg)[b]	Soil Cleanup Level (mg/kg) – Direct Contact Method B	Soil Cleanup Level (mg/kg) – Direct Contact Method C	Soil Concentrations (mg/kg) – Protective of Groundwater	Above Detection Limits
1, 4-Dichlorobenzene	7.10E-02	2.10E-01	1.85E+02	2.43E+04	1.34E-01	No
2-Butanone(MEK)	1.97E-02	5.83E-02	4.80E+04	2.10E+06	1.97E+01	No
4-Methyl-2-pentanone (MIBK)	1.71E-02	5.06E-02	6.40E+03	2.80E+05	2.73E+00	No
Antimony*	1.15E-01	3.40E-01	--	--	--	No
Arsenic*	1.52E+01	4.50E+01	6.67E-01	8.75E+01	3.41E-02	No
Benzo[a]pyrene*	1.25E-01	3.70E-01	1.37E-01	1.80E+01	2.32E-01	No
Bismuth	1.92E+01	5.68E+01	--	--	--	No
Boron	2.02E+00	5.98E+00	1.60E+04	7.00E+05	2.05E+02	No
Bromide	2.36E+01	6.99E+01	--	--	--	No
Cerium	2.53E+01	7.49E+01	--	--	--	No
Cobalt	1.05E+00	3.11E+00	2.40E+01	1.05E+03	4.34E+00	No
Dibenz[a, h]anthracene*	1.32E-01	3.91E-01	1.37E+00	1.80E+02	4.29E+00	No
Diethyl phthalate *	2.25E-01	6.66E-01	6.40E+04	2.80E+06	7.22E+01	No
Europium	1.01E+00	2.99E+00	--	--	--	No
Glycolate C2H3O3	2.52E+01	7.46E+01	--	--	--	No
Hexachlorobenzene*	9.46E-02	2.80E-01	6.25E-01	8.20E+01	8.77E-02	No

Table D-9. Average and 95% Upper Confidence Levels for Waste Residuals within Tank 241-C-102, Soil Cleanup Levels for Method B and C Direct Contact Exposure, and Soil Concentrations Protective of Groundwater.

Analyte	Average Concentration (mg/kg)[a]	95% Upper Confidence Level Concentration (mg/kg)[b]	Soil Cleanup Level (mg/kg) – Direct Contact Method B	Soil Cleanup Level (mg/kg) – Direct Contact Method C	Soil Concentrations (mg/kg) – Protective of Groundwater	Above Detection Limits
Lanthanum	1.01E+00	2.99E+00	--	--	--	No
Lithium	1.22E+00	3.61E+00	1.60E+02	7.00E+03	1.92E+02	No
m-Xylene	1.68E-03	4.97E-03	1.60E+04	7.00E+05	1.35E+01	No
m-Xylene	1.68E-03	4.97E-03	1.60E+04	7.00E+05	1.35E+01	No
N, N-Diphenylamine*	1.06E-01	3.14E-01	--	--	--	No
Neodymium	1.52E+01	4.50E+01	--	--	--	No
Niobium	6.07E+00	1.80E+01	--	--	--	No
N-Nitroso-N, N-dimethylamine*	9.78E-02	2.89E-01	1.96E-02	2.57E+00	--	No
o-Xylene	1.02E-03	3.02E-03	1.60E+04	7.00E+05	1.47E+01	No
Palladium	1.21E+01	3.58E+01	--	--	--	No
Pentachlorophenol*	1.20E-01	3.55E-01	2.50E+00	3.28E+02	3.47E-03	No
Phenol*	1.13E-01	3.34E-01	2.40E+04	1.05E+06	1.10E+01	No
Praseodymium	2.63E+01	7.78E+01	--	--	--	No
Rhodium	1.21E+01	3.58E+01	--	--	--	No
Rubidium	5.76E+01	1.70E+02	--	--	--	No

Table D-9. Average and 95% Upper Confidence Levels for Waste Residuals within Tank 241-C-102, Soil Cleanup Levels for Method B and C Direct Contact Exposure, and Soil Concentrations Protective of Groundwater.

Analyte	Average Concentration (mg/kg)[a]	95% Upper Confidence Level Concentration (mg/kg)[b]	Soil Cleanup Level (mg/kg) – Direct Contact Method B	Soil Cleanup Level (mg/kg) – Direct Contact Method C	Soil Concentrations (mg/kg) – Protective of Groundwater	Above Detection Limits
Ruthenium	5.06E+00	1.50E+01	--	--	--	No
Tantalum	5.06E+00	1.50E+01	--	--	--	No
Thallium*	1.52E+01	4.50E+01	--	--	2.28E-01	No
Toluene*	8.05E-04	2.38E-03	6.40E+03	2.80E+05	4.65E+00	No
Tungsten	1.62E+01	4.80E+01	--	--	--	No
Xylenes	4.08E-04	1.21E-03	1.60E+04	7.00E+05	1.46E+01	No
Yttrium	2.02E+00	5.98E+00	--	--	--	No

[a] Mean Concentrations taken from Table A-1, Appendix A of RPP-RPT-59129, *Tank 241-C-102 Residual Waste Inventory Estimates for Component Closure Risk Assessment.*

[b] 95% Upper Confidence Level Concentration = Mean Concentration + (1.96 × Mean Concentration × Relative Standard Deviation). Mean Concentrations and Relative Standard Deviation provided in Table A-1 in Appendix A of RPP-RPT-59129.

[c] As nitrate, not nitrogen in nitrate; to convert to nitrogen in nitrate divide this number by 4.43.

[d] As nitrite, not nitrogen in nitrite; to convert to nitrogen in nitrite divide this number by 3.29.

* Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List." Total Cr is assumed to be Chromium(III), insoluble salts.

-- = Value is not available

Table D-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Hazardous Constituents in 241-C-102 Tank Residual Wastes.

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-102 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Acetate	1.15E+02	--	--	--	Yes
Aluminum	2.61E+05	3.26E+00	7.46E-02	5.44E-01	Yes
Ammonia	2.50E+00	--	--	--	Yes
Barium*	6.35E+00	--	--	--	Yes
Beryllium*	1.40E+00	8.75E-03	2.00E-04	2.21E-02	Yes
Butylbenzylphthalate*	1.00E+00	1.90E-03	1.45E-05	7.76E-02	Yes
Cadmium*	1.17E+00	1.46E-02	3.34E-04	1.70E+00	Yes
Calcium	1.66E+02	--	--	--	Yes
Chloride	8.80E+01	--	--	8.80E-02	Yes
Chromium, Total*	1.17E+02	9.75E-04	2.23E-05	5.85E-02	Yes
Copper	8.66E+01	2.71E-02	6.19E-04	3.05E-01	Yes
Cyanide*	4.39E+01	9.15E-01	2.09E-02	4.53E+01	Yes
Di (2-ethylhexyl) phthalate (DEHP)	3.72E+00	5.21E-02	3.97E-04	2.78E-01	Yes
Di-n-butylphthalate*	6.60E-01	8.25E-05	1.89E-06	1.17E-02	Yes

Table D-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Hazardous Constituents in 241-C-102 Tank Residual Wastes.

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-102 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Fluoride	3.02E+03	6.29E-01	1.44E-02	1.05E+00	Yes
Formate+A2	1.18E+02	--	--	--	Yes
Hydroxide OH	7.36E+00	--	--	--	Yes
Iron	1.72E+03	3.07E-02	7.02E-04	3.05E-01	Yes
Lead*	4.46E+01	--	4.46E-02	1.49E-02	Yes
Magnesium	6.99E+01	--	--	--	Yes
Manganese	5.00E+02	4.46E-02	1.02E-03	9.99E-01	Yes
Mercury*	4.41E+00	1.84E-01	4.20E-03	2.11E+00	Yes
Molybdenum	2.43E+00	6.08E-03	1.39E-04	7.52E-02	Yes
Nickel*	6.15E+00	--	--	--	Yes
Nitrate	5.79E+03	1.02E-02	2.33E-04	3.22E+01	Yes
Nitrite	2.95E+03	1.23E-01	2.81E-03	2.23E+02	Yes
Oxalate	1.58E+02	--	--	--	Yes
Phosphate	7.44E+03	--	--	--	Yes

Table D-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Hazardous Constituents in 241-C-102 Tank Residual Wastes.

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-102 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Polychlorinated Biphenyls*	2.35E-02	4.70E-02	3.58E-04	--	Yes
Potassium	1.14E+02	--	--	--	Yes
Samarium	3.81E+01	--	--	--	Yes
Selenium*	2.48E-05	--	--	--	Yes
Silicon	8.97E+02	--	--	--	Yes
Silver*	5.90E+01	1.48E-01	3.37E-03	4.34E+00	Yes
Sodium	3.29E+04	--	--	--	Yes
Strontium	1.11E+01	2.31E-04	5.29E-06	1.64E-03	Yes
Sulfate	5.91E+02	--	--	5.91E-01	Yes
Tellurium	9.49E+00	--	--	--	Yes
Thorium	2.60E+02	--	--	--	Yes
Tin	2.09E+01	4.35E-04	9.95E-06	4.35E-04	Yes
Titanium	2.84E+01	--	--	--	Yes
Tributyl phosphate	4.53E+00	4.08E-02	3.11E-04	9.14E+00	Yes

Table D-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Hazardous Constituents in 241-C-102 Tank Residual Wastes.

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-102 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Uranium	6.38E+03	2.66E+01	6.08E-01	2.36E+01	Yes
Vanadium	5.85E+00	1.46E-02	3.34E-04	3.66E-03	Yes
Zinc	5.67E+01	2.36E-03	5.40E-05	9.50E-03	Yes
Zirconium	4.16E+02	--	--	--	Yes
1, 1, 2-Trichloroethylene	1.21E-03	5.57E-05	6.91E-07	1.92E-01	No
1, 4-Dichlorobenzene	7.10E-02	3.83E-04	2.92E-06	5.31E-01	No
2-Butanone(MEK)	1.97E-02	4.10E-07	9.38E-09	1.00E-03	No
4-Methyl-2-pentanone (MIBK)	1.71E-02	2.67E-06	6.11E-08	6.27E-03	No
Antimony*	1.15E-01	--	--	--	No
Arsenic*	1.52E+01	2.28E+01	1.74E-01	4.46E+02	No
Benzo[a]pyrene*	1.25E-01	9.13E-01	6.95E-03	5.38E-01	No
Bismuth	1.92E+01	--	--	--	No
Boron	2.02E+00	1.26E-04	2.89E-06	9.86E-03	No
Bromide	2.36E+01	--	--	--	No

Table D-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Hazardous Constituents in 241-C-102 Tank Residual Wastes.

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-102 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Cerium	2.53E+01	--	--	--	No
Cobalt	1.05E+00	4.38E-02	1.00E-03	2.42E-01	No
Dibenz[a, h]anthracene*	1.32E-01	9.64E-02	7.34E-04	3.08E-02	No
Diethyl phthalate *	2.25E-01	3.52E-06	8.04E-08	3.12E-03	No
Europium	1.01E+00	--	--	--	No
Glycolate C2H3O3	2.52E+01	--	--	--	No
Hexachlorobenzene*	9.46E-02	1.51E-01	1.15E-03	1.08E+00	No
Lanthanum	1.01E+00	--	--	--	No
Lithium	1.22E+00	7.63E-03	1.74E-04	6.35E-03	No
m-Xylene	1.68E-03	1.05E-07	2.40E-09	1.24E-04	No
m-Xylene	1.68E-03	1.05E-07	2.40E-09	1.24E-04	No
N, N-Diphenylamine*	1.06E-01	--	--	--	No
Neodymium	1.52E+01	--	--	--	No
Niobium	6.07E+00	--	--	--	No

Table D-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Hazardous Constituents in 241-C-102 Tank Residual Wastes.

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-102 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
N-Nitroso-N, N-dimethylamine*	9.78E-02	4.99E+00	3.80E-02	--	No
o-Xylene	1.02E-03	6.38E-08	1.46E-09	6.94E-05	No
Palladium	1.21E+01	--	--	--	No
Pentachlorophenol*	1.20E-01	4.80E-02	3.66E-04	3.46E+01	No
Phenol*	1.13E-01	4.71E-06	1.08E-07	1.03E-02	No
Praseodymium	2.63E+01	--	--	--	No
Rhodium	1.21E+01	--	--	--	No
Rubidium	5.76E+01	--	--	--	No
Ruthenium	5.06E+00	--	--	--	No
Tantalum	5.06E+00	--	--	--	No
Thallium*	1.52E+01	--	--	6.67E+01	No
Toluene*	8.05E-04	1.26E-07	2.88E-09	1.73E-04	No
Tungsten	1.62E+01	--	--	--	No

Table D-10. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for Average Concentrations of Selected Hazardous Constituents in 241-C-102 Tank Residual Wastes.

Analyte	Average Concentration (mg/kg)[a]	Ratio of Mean Concentrations in Tank 241-C-102 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Xylenes	4.08E-04	2.55E-08	5.83E-10	2.79E-05	No
Yttrium	2.02E+00	--	--	--	No

[a] Mean Concentrations taken from Table A-1, Appendix A of RPP-RPT-59129, *Tank 241-C-102 Residual Waste Inventory Estimates for Component Closure Risk Assessment.*

[b] As nitrate, not nitrogen in nitrate; to convert to nitrogen in nitrate divide this number by 4.43.

[c] As nitrite, not nitrogen in nitrite; to convert to nitrogen in nitrite divide this number by 3.29.

* Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List." Total Cr is assumed to be Chromium(III), insoluble salts.

-- = Value is not available

Table D-11. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Hazardous Constituents above Detection in 241-C-102 Tank Residual Wastes.

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-102 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Acetate	1.28E+02	--	--	--	Yes
Aluminum	2.72E+05	3.41E+00	7.78E-02	5.67E-01	Yes
Ammonia	2.95E+00	--	--	--	Yes
Barium*	9.16E+00	--	--	--	Yes
Beryllium*	1.76E+00	1.10E-02	2.51E-04	2.78E-02	Yes
Butylbenzylphthalate*	1.29E+00	2.46E-03	1.87E-05	1.00E-01	Yes
Cadmium*	1.33E+00	1.66E-02	3.80E-04	1.93E+00	Yes
Calcium	2.10E+02	--	--	--	Yes
Chloride	1.04E+02	--	--	1.04E-01	Yes
Chromium, Total*	2.46E+02	2.05E-03	4.68E-05	1.23E-01	Yes
Copper	1.26E+02	3.93E-02	8.99E-04	4.43E-01	Yes
Cyanide*	5.59E+01	1.17E+00	2.66E-02	5.77E+01	Yes

Table D-11. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Hazardous Constituents above Detection in 241-C-102 Tank Residual Wastes.

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-102 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Di (2-ethylhexyl) phthalate (DEHP)	5.97E+00	8.35E-02	6.36E-04	4.47E-01	Yes
Di-n-butylphthalate*	8.93E-01	1.12E-04	2.55E-06	1.58E-02	Yes
Fluoride	4.90E+03	1.02E+00	2.33E-02	1.70E+00	Yes
Formate+A2	1.58E+02	--	--	--	Yes
Hydroxide OH	1.48E+01	--	--	--	Yes
Iron	2.68E+03	4.78E-02	1.09E-03	4.74E-01	Yes
Lead*	6.70E+01	--	6.70E-02	2.23E-02	Yes
Magnesium	7.65E+01	--	--	--	Yes
Manganese	1.26E+03	1.12E-01	2.57E-03	2.51E+00	Yes
Mercury*	1.13E+01	4.71E-01	1.08E-02	5.42E+00	Yes
Molybdenum	2.77E+00	6.92E-03	1.58E-04	8.56E-02	Yes
Nickel*	9.42E+00	--	--	--	Yes

Table D-11. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Hazardous Constituents above Detection in 241-C-102 Tank Residual Wastes.

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-102 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Nitrate	6.85E+03	1.21E-02	2.76E-04	3.80E+01	Yes
Nitrite	3.42E+03	1.42E-01	3.26E-03	2.59E+02	Yes
Oxalate	1.79E+02	--	--	--	Yes
Phosphate	1.42E+04	--	--	--	Yes
Polychlorinated Biphenyls*	3.97E-02	7.94E-02	6.05E-04	--	Yes
Potassium	1.59E+02	--	--	--	Yes
Samarium	6.12E+01	--	--	--	Yes
Selenium*	3.13E-05	--	--	--	Yes
Silicon	9.81E+02	--	--	--	Yes
Silver*	1.16E+02	2.91E-01	6.65E-03	8.56E+00	Yes
Sodium	3.93E+04	--	--	--	Yes
Strontium	1.75E+01	3.64E-04	8.31E-06	2.58E-03	Yes

Table D-11. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Hazardous Constituents above Detection in 241-C-102 Tank Residual Wastes.

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-102 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Sulfate	6.17E+02	--	--	6.17E-01	Yes
Tellurium	1.02E+01	--	--	--	Yes
Thorium	4.78E+02	--	--	--	Yes
Tin	3.21E+01	6.69E-04	1.53E-05	6.69E-04	Yes
Titanium	4.34E+01	--	--	--	Yes
Tributyl phosphate	7.86E+00	7.07E-02	5.39E-04	1.59E+01	Yes
Uranium	1.20E+04	5.02E+01	1.15E+00	4.46E+01	Yes
Vanadium	9.48E+00	2.37E-02	5.42E-04	5.93E-03	Yes
Zinc	6.88E+01	2.87E-03	6.55E-05	1.15E-02	Yes
Zirconium	8.02E+02	--	--	--	Yes
1, 1, 2-Trichloroethylene	3.58E-03	1.65E-04	2.05E-06	5.70E-01	No
1, 4-Dichlorobenzene	2.10E-01	1.13E-03	8.65E-06	1.57E+00	No

Table D-11. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Hazardous Constituents above Detection in 241-C-102 Tank Residual Wastes.

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-102 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
2-Butanone(MEK)	5.83E-02	1.21E-06	2.78E-08	2.97E-03	No
4-Methyl-2-pentanone (MIBK)	5.06E-02	7.91E-06	1.81E-07	1.86E-02	No
Antimony*	3.40E-01	--	--	--	No
Arsenic*	4.50E+01	6.75E+01	5.14E-01	1.32E+03	No
Benzo[a]pyrene*	3.70E-01	2.70E+00	2.06E-02	1.59E+00	No
Bismuth	5.68E+01	--	--	--	No
Boron	5.98E+00	3.74E-04	8.54E-06	2.92E-02	No
Bromide	6.99E+01	--	--	--	No
Cerium	7.49E+01	--	--	--	No
Cobalt	3.11E+00	1.30E-01	2.96E-03	7.16E-01	No
Dibenz[a, h]anthracene*	3.91E-01	2.85E-01	2.17E-03	9.11E-02	No
Diethyl phthalate *	6.66E-01	1.04E-05	2.38E-07	9.23E-03	No

Table D-11. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Hazardous Constituents above Detection in 241-C-102 Tank Residual Wastes.

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-102 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Europium	2.99E+00	--	--	--	No
Glycolate C2H3O3	7.46E+01	--	--	--	No
Hexachlorobenzene*	2.80E-01	4.48E-01	3.41E-03	3.19E+00	No
Lanthanum	2.99E+00	--	--	--	No
Lithium	3.61E+00	2.26E-02	5.16E-04	1.88E-02	No
m-Xylene	4.97E-03	3.11E-07	7.10E-09	3.68E-04	No
m-Xylene	4.97E-03	3.11E-07	7.10E-09	3.68E-04	No
N, N-Diphenylamine*	3.14E-01	--	--	--	No
Neodymium	4.50E+01	--	--	--	No
Niobium	1.80E+01	--	--	--	No
N-Nitroso-N, N-dimethylamine*	2.89E-01	1.48E+01	1.12E-01	--	No
o-Xylene	3.02E-03	1.89E-07	4.31E-09	2.05E-04	No

Table D-11. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Hazardous Constituents above Detection in 241-C-102 Tank Residual Wastes.

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-102 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Palladium	3.58E+01	--	--	--	No
Pentachlorophenol*	3.55E-01	1.42E-01	1.08E-03	1.03E+02	No
Phenol*	3.34E-01	1.39E-05	3.19E-07	3.05E-02	No
Praseodymium	7.78E+01	--	--	--	No
Rhodium	3.58E+01	--	--	--	No
Rubidium	1.70E+02	--	--	--	No
Ruthenium	1.50E+01	--	--	--	No
Tantalum	1.50E+01	--	--	--	No
Thallium*	4.50E+01	--	--	1.97E+02	No
Toluene*	2.38E-03	3.72E-07	8.51E-09	5.12E-04	No
Tungsten	4.80E+01	--	--	--	No

Table D-11. Ratios of Concentrations to Cleanup Levels or Soil Concentrations Protective of Groundwater for 95% Upper Confidence Level Concentrations of Selected Hazardous Constituents above Detection in 241-C-102 Tank Residual Wastes.

Analyte	95% Upper Confidence Level Concentration (mg/kg)[a]	Ratio of 95% Upper Confidence Level Concentrations in Tank 241-C-102 Upper Bound Inventory of Residual Wastes to Soil Cleanup Standards			
		Direct Contact Method B (mg/kg)	Direct Contact Method C (mg/kg)	Soil Concentrations Protective of Groundwater (mg/kg)	Above Detection Limits
Xylenes	1.21E-03	7.55E-08	1.73E-09	8.25E-05	No
Yttrium	5.98E+00	--	--	--	No

[a] 95% Upper Confidence Level Concentration = Mean Concentration + (1.96 × Mean Concentration × Relative Standard Deviation). Mean Concentrations and Relative Standard Deviation provided in Table A-1, Appendix A of RPP-RPT-59129, *Tank 241-C-102 Residual Waste Inventory Estimates for Component Closure Risk Assessment.*

[b] As nitrite, not nitrogen in nitrite; to convert to nitrogen in nitrite divide this number by 3.29.

[c] As nitrate, not nitrogen in nitrate; to convert to nitrogen in nitrate divide this number by 4.43.

* Dangerous waste constituent per WAC 173-303-9905, "Dangerous Waste Constituents List." Total Cr is assumed to be Chromium(III), insoluble salts.

-- = Value is not available

Table D-12. Background Data for Selected Constituents for the Hanford Site.

Analyte Name	Analyte Symbol	Analyte Class	Units	Lognormal 90th Percentile Background Value	Maximum Background Value	Source of Background Value
Cesium-137	Cs-137	RAD	pCi/g	1.1	1.6	DOE/RL-96-12, Rev. 0
Cobalt-60	Co-60	RAD	pCi/g	0.0084	0.039	DOE/RL-96-12, Rev. 0
Europium-154	Eu-154	RAD	pCi/g	0.033	0.079	DOE/RL-96-12, Rev. 0
Europium-155	Eu-155	RAD	pCi/g	0.054	0.1	DOE/RL-96-12, Rev. 0
Gross Beta	--	RAD	pCi/g	23	25	DOE/RL-96-12, Rev. 0
Plutonium-238	Pu-238	RAD	pCi/g	0.0038	0.019	DOE/RL-96-12, Rev. 0
Plutonium-239/240	Pu-239-240	RAD	pCi/g	0.025	0.033	DOE/RL-96-12, Rev. 0
Potassium-40	K-40	RAD	pCi/g	17	20	DOE/RL-96-12, Rev. 0
Radium-226	Ra-226	RAD	pCi/g	0.82	1.2	DOE/RL-96-12, Rev. 0
Strontium-90	Sr-90	RAD	pCi/g	0.18	0.37	DOE/RL-96-12, Rev. 0
Thorium-232	Th-232	RAD	pCi/g	1.3	1.6	DOE/RL-96-12, Rev. 0
Total beta radiostrontium	--	RAD	pCi/g	0.18	0.37	DOE/RL-96-12, Rev. 0
Uranium-233/234	U-233/234	RAD	pCi/g	1.1	1.5	DOE/RL-96-12, Rev. 0
Uranium-234	U-234	RAD	pCi/g	1.1	1.5	DOE/RL-96-12, Rev. 0
Uranium-235	U-235	RAD	pCi/g	0.11	0.39	DOE/RL-96-12, Rev. 0

Table D-12. Background Data for Selected Constituents for the Hanford Site.

Analyte Name	Analyte Symbol	Analyte Class	Units	Lognormal 90th Percentile Background Value	Maximum Background Value	Source of Background Value
Aluminum	Al	Metal	µg/kg	1.18E+07	28,800,000	DOE/RL-92-24, Vol. 1, Rev. 4
Antimony*	Sb	Metal	µg/kg	130	385	ECF-HANFORD-11-0038
Arsenic*	As	Metal	µg/kg	6,470	27,700	DOE/RL-92-24, Vol. 1, Rev. 4
Barium*	Ba	Metal	µg/kg	132,000	480,000	DOE/RL-92-24, Vol. 1, Rev. 4
Beryllium*	Be	Metal	µg/kg	1,510	10,000	DOE/RL-92-24, Vol. 1, Rev. 4
Boron	B	Metal	µg/kg	3,890	5,860	ECF-HANFORD-11-0038
Cadmium*	Cd	Metal	µg/kg	563	2,900	ECF-HANFORD-11-0038
Calcium	Ca	Metal	µg/kg	1.72E+07	105,000,000	DOE/RL-92-24, Vol. 1, Rev. 4
Chromium	Cr	Metal	µg/kg	18,500	320,000	DOE/RL-92-24, Vol. 1, Rev. 4
Cobalt	Co	Metal	µg/kg	15,700	110,000	DOE/RL-92-24, Vol. 1, Rev. 4
Copper	Cu	Metal	µg/kg	22,000	61,000	DOE/RL-92-24, Vol. 1, Rev. 4
Iron	Fe	Metal	µg/kg	3.26E+07	68,100,000	DOE/RL-92-24, Vol. 1, Rev. 4
Lead*	Pb	Metal	µg/kg	10,200	74,100	DOE/RL-92-24, Vol. 1, Rev. 4
Lithium	Li	Metal	µg/kg	13,300	19,200	ECF-HANFORD-11-0038
Magnesium	Mg	Metal	µg/kg	7.06E+06	32,300,000	DOE/RL-92-24, Vol. 1, Rev. 4

Table D-12. Background Data for Selected Constituents for the Hanford Site.

Analyte Name	Analyte Symbol	Analyte Class	Units	Lognormal 90th Percentile Background Value	Maximum Background Value	Source of Background Value
Manganese	Mn	Metal	µg/kg	512,000	1,110,000	DOE/RL-92-24, Vol. 1, Rev. 4
Mercury*	Hg	Metal	µg/kg	13	29	ECF-HANFORD-11-0038
Molybdenum	Mo	Metal	µg/kg	470	3,170	ECF-HANFORD-11-0038
Nickel*	Ni	Metal	µg/kg	19,100	200,000	ECF-HANFORD-11-0038
Potassium	K	Metal	µg/kg	2.15E+06	7,900,000	ECF-HANFORD-11-0038
Selenium*	Se	Metal	µg/kg	780	840	Ecology Publication #94-115
Silver*	Ag	Metal	µg/kg	167	273	ECF-HANFORD-11-0038
Sodium	Na	Metal	µg/kg	690,000	6,060,000	DOE/RL-92-24, V.1, Rev.4
Thallium*	Tl	Metal	µg/kg	185	523	ECF-HANFORD-11-0038
Uranium	U	Metal	µg/kg	3,210	4,042	Isotopic Activity Conversion based on DOE/RL-96-12 values
Vanadium	V	Metal	µg/kg	85,100	140,000	DOE/RL-92-24, Vol. 1, Rev. 4
Zinc	Zn	Metal	µg/kg	67,800	366,000	DOE/RL-92-24, Vol. 1, Rev. 4
Ammonia	NH_3	Anion	µg/kg	9,230	26,400	DOE/RL-92-24, Vol. 1, Rev. 4
Chloride	Cl	Anion	µg/kg	100,000	1,480,000	DOE/RL-92-24, Vol. 1, Rev. 4
Fluoride	F^-	Anion	µg/kg	2,810	73,300	DOE/RL-92-24, Vol. 1, Rev. 4

Table D-12. Background Data for Selected Constituents for the Hanford Site.

Analyte Name	Analyte Symbol	Analyte Class	Units	Lognormal 90th Percentile Background Value	Maximum Background Value	Source of Background Value
Nitrate	NO_3^-	Anion	µg/kg	52,000	906,000	DOE/RL-92-24, Vol. 1, Rev. 4
Phosphate	PO_4^-	Anion	µg/kg	785	225,000	DOE/RL-92-24, Vol. 1, Rev. 4
Sulfate	SO_4^-	Anion	µg/kg	237,000	12,600,000	DOE/RL-92-24, Vol. 1, Rev. 4

* Dangerous waste constituent per *Washington Administrative Code* 173-303-9905, "Dangerous Waste Constituents List."

DOE/RL-92-24, *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analyte*, Rev. 4, Volume 1.

DOE/RL-96-12, *Hanford Site Background: Part 2, Soil Background for Radionuclides*, Rev. 0.

ECF-HANFORD-11-0038, *Soil Background for Interim Use at the Hanford Site*.

Ecology Publication #94-115, *Natural Background Soil Metals Concentrations in Washington State*.